Expert Report of Professor Daniel A. Sumner

Submitted August 13, 2018

Kelsey Cascadia Rose Juliana; Xiuhtezcatl Tonatiuh M.,
through his Guardian Tamara Roske-Martinez; et al.,
Plaintiffs,
v.
The United States of America; Donald Trump,
in his official capacity as President of the United States; et al.,
Defendants.

IN THE UNITED STATES DISTRICT COURT
DISTRICT OF OREGON

(Case No.: 6:15-cv-01517-TC)

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I. Qualifications

1. I am the Frank H. Buck, Jr., Distinguished Professor in the Department of Agricultural and Resource Economics at the University of California, Davis. I am also the Director of the University of California Agricultural Issues Center. In these positions, I conduct academic research, teach undergraduate and graduate students, and direct an applied research and outreach program related to public issues facing agriculture.

2. I received my Ph.D. in Economics from the University of Chicago in 1978. I hold Master's degrees in Economics from the University of Chicago and Michigan State University and an undergraduate degree in Agricultural Management from California State Polytechnic University in San Luis Obispo.

3. Prior to beginning my current position in January 1993 at the University of California, Davis, I served as the Assistant Secretary for Economics at the U.S. Department of Agriculture ("USDA"), where I was involved in policy formulation and analysis on a range of topics facing agriculture and rural America—from food and farm programs to trade, resources, and rural development. In my role as supervisor of the USDA's economics and statistics agencies, I was also responsible for data collection, outlook, and economic research.

4. From 1978 to 1992, I was a professor in the Department of Economics and Business at North Carolina State University. I spent much of the period after 1986 on leave for government service in Washington, D.C. From 1987 to 1989, I was a Senior Staff Economist on the President's Council of Economic Advisers, and from 1990 to early 1992 I was Deputy Assistant Secretary for Economics at the USDA.

5. I have published widely in academic journals, books, and industry outlets. Because my work has focused on vital issues for the economics of agriculture, I have studied impacts and related issues surrounding climate change and greenhouse gas ("GHG") mitigation for more than 20 years. This is reflected in my academic articles and studies for government agencies involved in climate policy. For example, I have helped the California Air Resources Board examine economic tradeoffs inherent in potential GHG mitigation strategies.

6. Both climate change and agricultural markets are global, and it is logical to study the economic implications and mitigation of climate change in the context of international

agricultural markets. For example, I have conducted research to evaluate the relationship between corn price increases, driven in part by U.S. ethanol subsidies, and water quality impacts that spill into the Gulf of Mexico. These results, which required collaboration with agronomist crop modelers, highlighted how unintended and unexpected negative environmental consequences can be caused by a policy motivated, in part, by a different environmental goal. In other papers, I have considered even broader global implications for food and policy, recognizing that impacts of climate change are likely to be most severe on agriculture near the equator, which is also home to some of the world's poorest people—among them many farmers and their families.

7. Some of my climate-related work has been local, such as investigating how areas allocated to different crops have adjusted and are likely to adjust to climate change in the Central Valley of California, or how pastures adjust to changes in snow cover that affects grazing potential.

8. I have won numerous awards for my research, outreach, and publications. In 1995, I was honored by the American Agricultural Economics Association ("AAEA") for my agricultural policy contributions. In 1996, my co-authors and I won the AAEA award for Quality of Research Discovery. I also received the award for Quality of Communication in 1996. In 1998, I was named a Fellow of the AAEA, which is the highest honor awarded to its members. In 2006, my co-authors and I won the award for best article in the *Australian Journal of Agricultural and Resource Economics* and the award for Quality of Communication from the Australian Society of Agricultural and Resource Economics. In 2015, my co-authors and I won the award for Best Journal Article in the *American Journal of Agricultural Economics*. Also in 2015, I was honored to present the Fellows Lecture at the annual meeting of the Agricultural and Applied Economics Association. Finally, in 2016 my co-authors and I won the best article prize from the International Association of Agricultural Economists.

9. From 2001 to 2003 I sat on the USDA Agricultural Policy Advisory Committee for Trade, and in 2002 I was named a Fulbright Senior Specialist Scholar for Australia. I have given honorary lectures and keynote addresses to national and international meetings in many countries and served on numerous academic panels and boards. I have testified before the U.S. Congress and before the U.S. International Trade Commission, the Canadian International Trade Tribunal,

and several times before dispute resolution panels and the Appellate Body of the World Trade Organization in Geneva, Switzerland. This testimony has covered a variety of agricultural policy topics, including the economic impacts of Country of Origin Labeling.

10. My curriculum vitae, including a list of my publications, is attached as Appendix A. A list of my prior testimony for the most recent four years is attached as Appendix B.

II. Background and Assignment

11. Plaintiffs allege that Defendants—certain federal government agencies and the public officials who direct them—have violated Plaintiffs' rights under the Fifth and Ninth Amendments of the Constitution through (i) affirmative policy acts that subsidize the fossil fuel industry and facilitate the consumption of fossil fuels; (ii) direct consumption of fossil fuels; and (iii) inaction and failure to adopt policies that encourage a shift to zero-carbon energy sources.[1,2]

12. Plaintiffs allege that the USDA, the U.S. Forest Service ("USFS"), and the Bureau of Land Management ("BLM") have "substantially contributed to … a dangerous climate system."[3] Plaintiffs specifically allege that the USDA, the USFS (a unit within USDA, and BLM (a unit within the U.S. Department of the Interior) have authorized 25% of U.S. coal production; issued leases and mining permits authorizing the extraction of coal, oil, and gas from public lands; permitted large-scale logging in national forests; supported pollution-generating farming and agricultural practices; and failed to protect the nation's National Forests as a carbon sink.[4]

13. Plaintiffs demand that the Court "order Defendants to cease their permitting, authorizing, and subsidizing of fossil fuels and, instead, move to swiftly phase out CO2 emissions, as well as take such other action as necessary to ensure that atmospheric CO2 is no more concentrated than 350 ppm by 2100, including to develop a national plan to restore Earth's energy balance, and

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[1] Defendants include the United States of America, the President of the United States, the Office of the President of the United States, Department of Energy, Department of the Interior ("DOI"), Department of Transportation, Department of Agriculture, Department of Commerce, Department of Defense, Department of State, and United States Environmental Protection Agency ("EPA"). See First Amended Complaint for Declaratory and Injunctive Relief, *Kelsey Cascadia Rose Juliana et al. v. The United States et al.*, September 10, 2015 ("Complaint"), p. 2.

[2] Complaint, ¶¶286, 303–305.

[3] Complaint, ¶117.

[4] Complaint, ¶117.

implement that national plan so as to stabilize the climate system."[5] Plaintiffs claim that meeting their demand for relief "would require a near-term peak in CO2 emissions and a global reduction in CO2 emissions of at least 6% per year, alongside approximately 100 gigatons of carbon drawdown this century from global reforestation and improved agriculture."[6]

14. Plaintiffs have submitted the expert report of Dr. G. Philip Robertson as evidence that changes in land management practices in agriculture and forestry can contribute to negative emissions ("sequestration") and avoided future emissions ("mitigation").[7] Dr. Robertson concludes that "changes to land management practices in the U.S. could mitigate more than 30 GtCeq between 2020 and 2100."[8,9]

15. I have been asked by counsel for Defendants in this matter to evaluate the policy requirements, the feasibility, and the broader consequences of implementing the land management practices Dr. Robertson proposes in his report.

16. The opinions and analysis set forth in this report are my own. Cornerstone Research has assisted me in the preparation of this report; their staff have worked under my direction. My compensation in this matter is $700 per hour. I receive compensation from Cornerstone Research based on its collected staff billings for its support of me in this matter. Neither my compensation in this matter nor my compensation from Cornerstone Research is in any way contingent or based on the content of my opinion or the outcome of this or any other matter. A list of materials that I relied upon in forming the opinions in this report is provided in Appendix C. I understand that this litigation is ongoing, and I reserve the right to update my opinion as additional materials are made available to me.

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[5] Complaint, ¶12.

[6] Complaint, ¶258.

[7] Expert Report of Dr. G. Philip Robertson, April 13, 2018 ("Robertson Report").

[8] Robertson Report, p. 2.

[9] For purposes of this report, carbon refers to carbon equivalents. GtC denotes a gigaton of carbon, equivalent to 1 billion metric tons of carbon. MtC denotes 1 million metric tons of carbon. A metric ton in turn is 1,000 kilograms, or 2,205 lb. (1 GtC = 1 petagram C = 3.67 Gt carbon dioxide). Carbon equivalent (Ceq) describes greenhouse gases in a common unit. For any greenhouse gas, Ceq is calculated as the amount of carbon which would have the equivalent global warming impact. Thus, 1 GtCeq describes the mass of a mix greenhouse gases whose global warming impact is equivalent to 1 gigaton of carbon. For a summary of global warming impacts for different greenhouse gases, see Matthew Brander, "Greenhouse Gases, CO2, CO2e, and Carbon: What Do All These Terms Mean?," ecometrica, August 2012, https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf.

III. Summary of Conclusions

17. By virtue of Defendants' answer, I understand that the existence of climate change, man's primary contribution to climate change, and the need for global action to address the risks of climate change are not at issue in this lawsuit. Also in light of Defendants' answer, this report does not take issue with the notion that global greenhouse gas emissions should be reduced or that methods for carbon sequestration should be explored further. My main thrust in this report is to emphasize that one cannot abandon economic (and, to my mind, common-sense) principles for allocation of scarce resources. As a society, we must carefully consider the full costs and unintended consequences of steps proposed for various endeavors—including addressing climate change.

18. My conclusions are as follows:

a. Dr. Robertson's failure to provide information about the costs of his proposed agricultural methods severely limits the value of his report as a guide to public policy. Whether or not his proposed methods can provide the GHG abatement benefits set forth in his report, absent information about costs Dr. Robertson cannot demonstrate that investment in his proposed methods would be a reasonable, cost-effective use of scarce resources to address the problem of climate change. Assuming for purposes of argument that Dr. Robertson's methods are technically viable, I find that investment in the methods he proposes and on the scale that he proposes would likely be a wasteful allocation of public and private resources. I discuss this conclusion in Section V.

b. Dr. Robertson also fails to explain the impact of his proposed methods on (i) the cost and availability of food in the United States and globally; (ii) incomes and employment in rural communities; or (iii) other environmental and conservation objectives. Further, he fails to account for the possibility that use of cost-increasing or yield-reducing methods in the United States may displace agricultural production to other countries in which the carbon intensity of production is higher, which could increase GHG emissions on a net basis. As I explain below, there is precedent for this outcome; legislation mandating the use of advanced biofuels in U.S. gasoline led to precisely this outcome.

c. I conclude that there is considerable doubt as to whether Dr. Robertson's proposed agricultural methods can deliver the amount of GHG abatement that Dr. Robertson claims at any price. Research, some of it conducted by Dr. Robertson himself in his academic role, demonstrates that some of his proposed methods are not technically viable; that others are not economically feasible; and that for others, an abatement amount cannot be reliably estimated. These methods account for nearly half of the total abatement that Dr. Robertson claims in his report. Moreover, USDA research indicates that, even after correcting for these issues, Dr. Robertson's conclusion as to the potential amount of abatement is implausibly large. I explain these conclusions in Section VII.

d. Finally, I conclude that Plaintiffs' allegations with respect to the government's agricultural and forestry policies fail to recognize that government policy makers must balance multiple policy objectives that often conflict. Moreover, government policy makers have taken a number of affirmative steps to encourage GHG abatement in agriculture and forestry. When government policy makers elect not to mandate or use other measures to achieve the adoption of methods for GHG abatement, they often do so because the supporting scientific evidence is inconclusive or because a cost-effective policy to facilitate adoption of the practice does not exist. I discuss this conclusion in Section VIII.

IV. Summary of Dr. Robertson's Opinions

19. Dr. Robertson proposes a set of land management practices ("methods") that, in his opinion, could provide approximately 31 gigatons of carbon equivalent ("GtCeq") of GHG abatement from 2020 to 2100 (his "proposal").[10] Dr. Robertson states that his proposed methods may remove from the atmosphere ("sequester") approximately 21 GtCeq of GHG emissions and prevent the emission of ("mitigate") an additional 10 GtCeq of GHG emissions from 2020 to

[10] Robertson Report, p. 2. Throughout this report I use the term "abatement" to refer to "sequestration" and "mitigation" collectively. To arrive 31 GtCeq, Dr. Robertson first calculates an annual amount of GHG abatement for each of his proposed methods, and computes cumulative abatement either through 2100 or to the point at which, in Dr. Robertson's opinion, the proposed method will no longer sequester carbon because the soil reaches its carbon saturation point. See Robertson Report, p. 9 ("soils tend to have a saturation level above which no further soil carbon increase is likely possible.").

2100.[11] According to Dr. Robertson, GHG abatement at this scale represents more than 30% of the 100 GtCeq reduction required after "limiting total cumulative fossil fuel emissions to 500 GtC" to reduce global CO2 concentrations to 350 parts per million by 2100.[12,13]

20. Dr. Robertson's proposed sequestration methods include cropland management, cropland conversion to perennial grasses, management of grazing lands and livestock grazing practices, wetlands restoration, and forest management.[14] Proposed practices for emissions mitigation include improved nitrogen fertilizer efficiency, improved rice water management, and shifting to cellulosic bioenergy production on land now used for grain ethanol and on marginal lands.[15,16]

21. Dr. Robertson acknowledges that some of his proposed methods are already practiced.[17] Dr. Robertson indicates that his proposed methods should be implemented within the United States on the largest scale possible.[18] He acknowledges that large-scale implementation would increase costs of production on farms and ranches (and his proposal thus depends on the adoption of policies to offset cost increases). He notes that farms, ranches, and landowners have been willing to accept payments to implement GHG abatement practices and opines that policies

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[11] According to the EPA, total U.S Greenhouse Gas Emissions in 2016 was 6,511 million metric tons of CO2eq, or 1.8 GtC. See "Sources of Greenhouse Gas Emissions," *EPA*, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#colorbox-hidden.

[12] Robertson Report, pp. 2, 6. As of 2015 the global fossil fuel emissions related to burning fossil fuels totaled 8.9 GtC, following three years of a slight decline in global fossil fuel emissions. See "International Energy Statistics," U.S. Energy Information Administration, https://www.eia.gov/beta/international/, accessed August 10, 2018.

[13] According to Plaintiffs' expert James Hansen, "Fossil fuel emissions through 2012 total ~370 GtC (Fig. 2). If subsequent emissions decrease 6%/year, additional emissions are ~130 GtC, for a total ~500 GtC fossil fuel emissions [in 2100]." See James Hansen et al., "Assessing 'Dangerous Climate Change': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature," PLoS ONE 8(12): e81648, December 2013, pp. 1–26 at p. 15.

[14] Dr. Robertson's proposed sequestration methods include no-till adoption; reduced summer fallow; winter cover crops; diversified crop rotations; manure and compost additions; set-aside highly erodible cropland; cellulosic bioenergy on grain and marginal lands; improved stocking rates on rangeland and improved species composition; improved soil management for timberland and agroforestry; and improved stand management. See Robertson Report, Table 2.

[15] Robertson Report, Table 2.

[16] Cellulosic bioenergy refers to the production of biofuel, typically ethanol, from cellulose produced by plants, rather than from a plant's seeds or fruit (e.g., grain-based ethanol produced from corn).

[17] Robertson Report, p. 9 ("And some practices are already implemented to limited degrees.")

[18] Robertson Report, p. 9 ("The maximum extents possible are, of course, constrained by available land area; all private and public lands within the conterminous U.S. (the lower 48 states), on which Section 5 estimates are based, contains 159 Mha of cropland, 265 Mha of rangeland and pasture, and 256 Mha of forest lands").

for payment would be a necessary component of his proposal.[19] Dr. Robertson thus appears to assume that subsidy payments would be the appropriate policy instrument, rather than taxation, cap-and-trade, or a command-and-control approach, but he provides no support or evidence for this assumption.

V. Dr. Robertson Fails to Show (and Cannot Show) That His Proposed Practices Would Improve Well Being for Current or Future Generations

22. Putting aside questions about the technical efficacy of Dr. Robertson's proposed methods, the fundamental question in evaluating his report is whether investment in Dr. Robertson's proposed methods would be the best use of scarce resources in tackling the problem of climate change. As I explain in this section, Dr. Robertson fails to provide the information necessary to address this question. Further, published research, some of it written by USDA scientists or supported by the USDA, demonstrates that Dr. Robertson's proposed methods may represent wasteful approaches to dealing with the crucial issue of climate change mitigation, and thus would be less likely to achieve GHG abatement objectives and climate goals than other methods.

A. Resource allocation principles for curbing climate change

23. Because society's resources are finite, even when facing a problem as serious as climate change, it is critical that in responding to the problem, government policy makers allocate available resources to GHG abatement efforts in a manner that improves social well-being. Policy makers can ensure efficient resource allocation in addressing climate change by asking two central questions when considering potential GHG abatement projects.

24. First, does the full cost to society of a proposed GHG abatement project exceed the social value that society places on GHG abatement? I use the term "costs" in a broad, inclusive sense. Rather than thinking of costs narrowly as the direct financial investment in a project (e.g., government payments to farmers to adopt no-till), the economic science defines costs to include

[19] Robertson Report, p. 28 ("Without supportive federal policies and payments sufficient to cover costs, farmers, ranchers, and forest owners are unlikely to participate in sufficient numbers to effect meaningful change").

the non-pecuniary and indirect effects of the project. Similarly, economics defines social benefits broadly to include the contribution to the full set of society's goals.

25. As I explain more fully later in this section, the cost of widespread adoption of an agricultural practice includes not only the direct financial impact on farms (e.g., lost revenue due to reduced yield), but also the impact on related farm commodity markets and any positive or negative environmental impacts. Money is often used as a common measure for these effects, but the core issue is taking into account all effects that have value to society. Similarly, the term "value" as used in this question is usually defined broadly to include the benefits of GHG abatement in terms of the many impacts of climate on society as well as benefits to other countries and future generations.

26. The second central question asks whether the GHG abatement value of the proposed project exceeds the value of what is given up to achieve the abatement, or, in economic terms, the "opportunity cost" of the proposed project. Policy makers must carefully examine whether a proposed project offers the greatest amount of GHG abatement per unit of cost (defined broadly), or whether other abatement projects offer a higher payoff for the cost incurred. In the context of Dr. Robertson's proposal, this means that we should ask whether other projects that can help the United States meet its GHG abatement goals, such as research and development for electric vehicles or low-carbon manufacturing processes, offer a higher level of GHG abatement per unit of cost than the methods that Dr. Robertson proposes. To do anything else would simply waste limited resources.

27. To address the two resource allocations questions discussed above, policy analysts examine the incremental value and incremental cost of GHG abatement, or in the language of economics, the *marginal* value and *marginal* cost of GHG abatement. The intuition here (and, crucially, the empirical reality) is that the value of GHG abatement decreases at the margin as we undertake more abatement. The first gigaton of GHG abatement has greater value to society, in terms of climate outcomes for example, than, say, the 50th or 100th gigaton. Similarly, the cost of abatement increases at the margin as society invests in larger amounts of abatement. That is, increasing abatement is increasingly expensive. However, so long as the marginal value of GHG abatement exceeds its marginal cost, society is made better off by devoting additional resources

to additional abatement. Social well-being is maximized when the marginal cost of abatement is equal to the marginal value of abatement.[20]

28. Applying the marginal analysis framework requires specific information about the marginal value and marginal cost of GHG abatement. An appropriate economic measure of the marginal value of abatement to society is the cost of the damage (or, equivalently, the value of *avoiding* the damage) associated with a unit of GHG emissions. This measurement can be thought of as the price of GHG *avoidance*, i.e., the price that society would be willing to pay to avoid one ton of GHG emissions and the attendant harm. It is efficient (i.e., improves social well-being) for society to pay farmers, ranchers, and other resource owners to adopt certain abatement methods, so long as the cost of those methods (per ton of GHG abatement) is less than the damage associated with the GHG emissions. Similarly, social well-being increases when we obtain the most GHG abatement possible out of a given resource investment. To do otherwise would be to waste scarce social resources and impose a loss of well-being on society.

B. Dr. Robertson fails to provide costs for his proposed methods

29. Dr. Robertson fails to provide the information necessary to apply the resource allocation principles discussed above. His report contains no useful or meaningful information about the cost of his proposed methods. Dr. Robertson does acknowledge that his proposed methods would increase costs for farm, ranch, and forest operations, and that the GHG abatement he claims to provide would not materialize "without supportive federal policies and payments sufficient to cover costs."[21] However, mere acknowledgment that farm costs would increase is not sufficient to address the fundamental question, namely, whether investment in his proposed methods would be the best use of scarce resources to address the problem of climate change. This is a glaring omission, particularly in light of the fact that in his academic research

[20] Abram Bergson, "A Reformulation of Certain Aspects of Welfare Economics," *Quarterly Journal of Economics* 52, No. 2, February 1938, pp. 310–334.

[21] As mentioned above, Dr. Robertson assumes that support for GHG-mitigating practices will take the form of government subsidy payments. He offers no basis for this assumption. There are many policy instruments that may be preferable to subsidy payments, including cap-and-trade, taxing emissions, or a command-and-control approach to agricultural GHG emissions. See Robertson Report, p. 28. I understand, based on my experience as a USDA official, that each of these options requires legislation from Congress.

Dr. Robertson explicitly recognizes the relationship between the costs and benefits of other ecological services that farms can supply.[22]

30. Without information as to costs, Dr. Robertson has no basis to determine whether the cost of any of his proposed methods is less than the beneficial value of the expected GHG abatement, or whether, instead, the cost to society of the proposed methods exceeds the value of the expected abatement. In the first case, society would be better off implementing his proposed methods, while in the second case, implementation would be a misallocation of society's scarce resources. Reasonable guidelines for policy evaluation (and those included in Federal rules) call for precisely the same balancing of expected costs and benefits to society.[23]

31. The lack of cost information also makes it impossible to determine whether the abatement value of Dr. Robertson's proposed methods exceeds their opportunity cost. For example, it may be that investing resources in no-till agriculture or reducing summer fallow would yield more GHG abatement if invested instead in other projects, such as livestock manure management, R&D for electric cars, or land management practices in other countries.

32. In sum, even if Dr. Robertson's proposed methods are technically feasible, the cost of adopting his methods may exceed the value of the GHG abatement his proposed methods purportedly provide. More precisely, if the marginal cost of his proposed methods exceeds the marginal value of the abatement the method provides, then the economically efficient amount of GHG abatement that Dr. Robertson's proposed methods provide could be substantially less than the amount of GHG abatement claimed in his report.

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[22] G. Philip Robertson et al., "Farming for Ecosystem Services: An Ecological Approach to Production Agriculture," in The Ecology of Agricultural Landscapes: Long-Term Research on the Path to Sustainability, ed. S. K. Hamilton et al. (New York: Oxford University Press, 2015), p. 34 ("Farming for services requires knowledge of what services can be practically provided at what cost and how nonprovisioning services might be valued in the absence of markets. The costs of providing services are both direct (e.g., the cost of installing a streamside buffer strip) and indirect (e.g., the opportunity cost of sales lost by installing such a strip on otherwise productive cropland). Moreover, valuation includes not simply the monetary value of a provided service but also what society (consumers) might be willing to pay through mechanisms such as higher food prices or taxes.").

[23] US Office of Management and Budget Memo, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Circular No. A-94, undated, p. 6, https://obamawhitehouse.archives.gov/omb/circulars_a094#6 ("Analyses should include comprehensive estimates of the expected benefits and costs to society based on established definitions and practices for program and policy evaluation.").

C. Research suggests that Dr. Robertson's proposed methods are likely to be wasteful

33. A USDA analysis of marginal abatement costs published in 2013 and 2016 suggests that Dr. Robertson's proposed methods are likely to be socially inefficient. Thus, even if Dr. Robertson's land management methods work as assumed, the abatement that he claims to provide would not be the best use of society's scarce resources.

1. Marginal abatement costs

34. USDA commissioned and contributed to research by an independent research firm, ICF, in order to understand the marginal abatement costs associated with a variety of agricultural and land management practices.[24] ICF analyzed the mitigation potential of approximately 20 different agricultural methods across a variety of domains— including crop production systems, animal production systems, and land retirement systems—and computed marginal abatement costs for many of these methods.[25] The marginal abatement cost for a given method, which ICF refers to as the "break-even price," measures the net amount by which a farm's profit would change (i.e., change in revenue net of change in costs) upon adopting the practice, divided by the GHG abatement created by the practice.[26] In other words, the marginal abatement cost for a given practice measures the minimum amount that a farm would have to receive (per ton of GHG abatement) to offset the changes in profits associated with use of that practice. For example, ICF concludes that to convert from conventional tillage to no-till methods, corn growers in the Corn Belt region would require a payment of $125 per tCeq to offset the incremental cost of adopting

[24] ICF published two reports documenting its findings: "Greenhouse Gas Mitigation Options and Costs for Agricultural Land and Animal Production within the United States," USDA Report No. AG-3142-P-10-0214, February 2013, ("ICF 2013 Report"); and "Managing Agricultural Land for Greenhouse Gas Mitigation within the United States," USDA Report No. AG-3144-D-14-0292, July 2016, ("ICF 2016 Report"). ICF has extensive experience working with the United States and other governments on research related to climate change. See "Climate," *ICF*, https://www.icf.com/work/climate, accessed August 3, 2018. The lead authors of the ICF reports are leading researchers who have published in peer-reviewed academic journals. Contributors to the ICF reports have also been co-authors with Dr. Robertson.

[25] ICF 2016 Report, p. 1. ICF limited its analysis and reporting of cost information to practices for which adoption costs and mitigation values were available in the scientific literature, published government reports, and other sources.

[26] ICF calculated marginal abatement costs by region and crop using a discounted cash-flow analysis that identifies net impact of a GHG mitigation strategy on a farm's profits (i.e., changes in revenue and changes in costs). The variables considered within ICF's calculation are yearly emission reduction, yearly revenue, lifetime of the option, discount rate, one-time capital costs, yearly operating costs or cost savings, business tax rate, and tax break from depreciation. See ICF 2013 Report, p. 1.3; ICF 2016 Report, pp. 2–3.

no-tillage farming, including the use of additional herbicides and lost revenues.[27] Importantly, marginal abatement costs computed by ICF do not include additional monitoring and measurement costs necessary to confirm that new agricultural practices in fact yield GHG abatement. Thus ICF's cost estimates do not reflect the full cost to society of achieving the stated GHG abatement amounts.

35. The ICF analysis includes marginal abatement costs for two of Dr. Robertson's proposed methods: no-tillage and reduced fertilizer usage.[28] For these two methods, ICF examined marginal abatement costs and provided the data necessary to construct marginal abatement cost curves.[29]

36. Figure 1 presents the marginal abatement cost curve for these two methods on a combined basis.[30] Each point on the curve displays the marginal cost for a given level of annual GHG abatement; the amount of annual abatement is shown on the horizontal axis, and the corresponding cost is shown on the vertical axis. Marginal cost increases as the amount of annual abatement increases. In other words, increasing annual quantities of GHG abatement are increasingly expensive.

[27] ICF 2013 Report, p. 2.14.

[28] Marginal abatement costs are taken from break-even prices included in the ICF 2013 Report. ICF assumed a 10% reduction in fertilizer usage, while Dr. Robertson assumed a 15% reduction. ICF also calculated marginal abatement cost curves for frost legume interseeding; however, Dr. Robertson is not clear in his report whether he is proposing frost or normal legume interseeding. See Robertson Report, pp. 15–16. Therefore, I do not examine marginal abatement costs for that method.

[29] Break-even prices represent "the payment level at which a farm will view the economic benefits and the economics costs associated with adoption as exactly equal." Only instances in which switching methods decreased yield are included in ICF's break-even analyses. This is because, "[w]ithout yield penalties, the break-even prices are consistently negative." "A negative break-even price suggests the following: (1) no additional incentive should be required to make adoption cost-effective; or (2) there are non-pecuniary factors (such as risk or required learning curve) that discourage adoption." See ICF 2013 Report, pp. 1.3, 2.13, 2.26.

[30] ICF reports abatement amounts and costs in terms of CO2. Because Dr. Robertson reports values in terms of "carbon" abatement, I have converted values reported by ICF equivalent values in carbon. To do so, I apply the accepted standard factor of 3.67 to CO2 prices and the standard factor of 1/3.67 to tons of CO2eq. For explanation and documentation on the conversion factor, see United States EPA, *Greenhouse Gas Mitigation Potential in US Forestry and Agriculture,* 2005, Chapter 4, Table 4-2.

37. Figure 1 shows that:

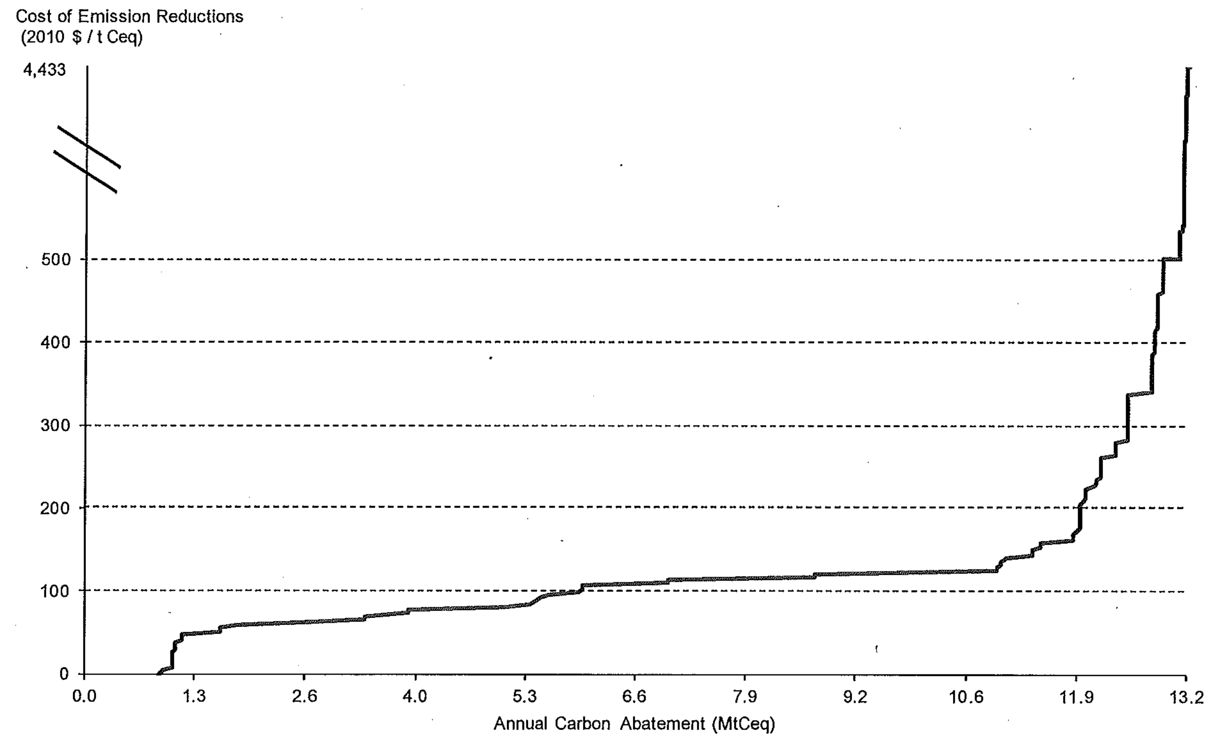
- Obtaining even half of the theoretically available annual abatement estimated by ICF (13.2 MtCeq) for no-till and reduced fertilizer usage would be quite costly; the marginal cost of annual abatement at 6.6 MtCeq exceeds $100 per tCeq;
- Obtaining the full amount of annual abatement estimated as potentially available by ICF would clearly be prohibitively costly. The marginal cost of annual abatement increases to $4,433 per tCeq.

38. Further, comparing Figure 1 to Dr. Robertson's Table 2 reveals that Dr. Robertson's conclusion as to the total annual abatement available from no-tillage farming and reduced fertilizer usage is dramatically larger than ICF's estimate. ICF concludes that potential annual abatement is 13.2 MtCeq while Dr. Robertson concludes 87.0 MtCeq of abatement per year, or more than six times the amount reported by ICF.[31] I discuss this point further in Section VII.

[31] Robertson Report, Table 2. Dr. Robertson reports annual abatement totals of 37.6 MtCeq for no-till adoption and 49.4 MtCeq for avoided nitrous oxide and CO2 emissions.

Figure 1

ICF Marginal Abatement Costs for No-Till and Reduced Fertilizer Use



Source: Calculated using data from the ICF 2013 Report

39. Further comparison of the ICF reports and Dr. Robertson's report is instructive. Both ICF and Dr. Robertson respond to the same question, namely, what are the GHG abatement benefits to be achieved from changes in agricultural and land management practices in the U.S.?[32]

[32] ICF 2016 Report p. 1, ("This report presents an analysis of the greenhouse gas (GHG) mitigation potential associated with changes in U.S. agricultural management practices."). Robertson Report, p. 1 ("I…have been retained…to provide expert testimony about the potential capacity for improved management of United States forest, range, and agricultural lands to achieve net negative carbon emissions and avoid future greenhouse gas emissions. …I provide… a quantitative assessment of the potential for changes in management practices to provide meaningful greenhouse gas mitigation.").

40. Despite examining the same question, Dr. Robertson and ICF reach dramatically different conclusions as to both the amount of annual GHG abatement attainable from changes in agricultural methods and the methods that can yield GHG abatement.

- ICF estimates that changes to U.S. agricultural methods could yield up to 33 MtCeq of GHG abatement annually at carbon prices ranging from $1 to $367 per tCeq.[33] (For an illustration, see Figure 2.)
- Dr. Robertson concludes instead that adoption of his proposed methods would yield annual GHG abatement of 535 MtCeq, *sixteen* times the annual GHG abatement that ICF reports.[34]
- Dr. Robertson's estimate includes a number of methods that ICF chose to exclude from its analysis, and vice-versa.

41. I discuss these differences further in Section VII.

42. ICF's estimates of marginal abatement costs are informative and useful in considering the potential costs of Dr. Robertson's proposed methods of GHG abatement. They can serve as a proxy (albeit approximate) for the cost of Dr. Robertson's proposed methods, with the important caveat that ICF studied some methods that Dr. Robertson did not study, and vice versa.

43. Figure 2 displays ICF's estimate of the annual GHG abatement amount available from all the methods it studied, and the marginal cost of abatement, just as in Figure 1.[35] Each point on the curve displays the marginal cost for a given amount of annual GHG abatement; the amount of annual abatement is shown on the horizontal axis, and the corresponding cost per ton is shown on the vertical axis.

[33] At an abatement quantity of 32.7 MtCeq, the marginal cost of abatement is $367 per MtCeq. See ICF 2016 Report, Figure 1, p. 3. Note that ICF reports results in terms of CO2 abatement and CO2 prices (up to 120 tons of CO2eq abatement at CO2 prices ranging from $1 to $100 per metric ton of CO2).

[34] Notably, Dr. Robertson implies that his methods could be provided at a cost no more than $367 per ton. "Griscom et al., for example, state that 1/3 of the potentials they consider could be provided at this cost [$36.70 tCeq], with the remainder requiring no more than [$367 tCeq]." Robertson Report, p. 27.

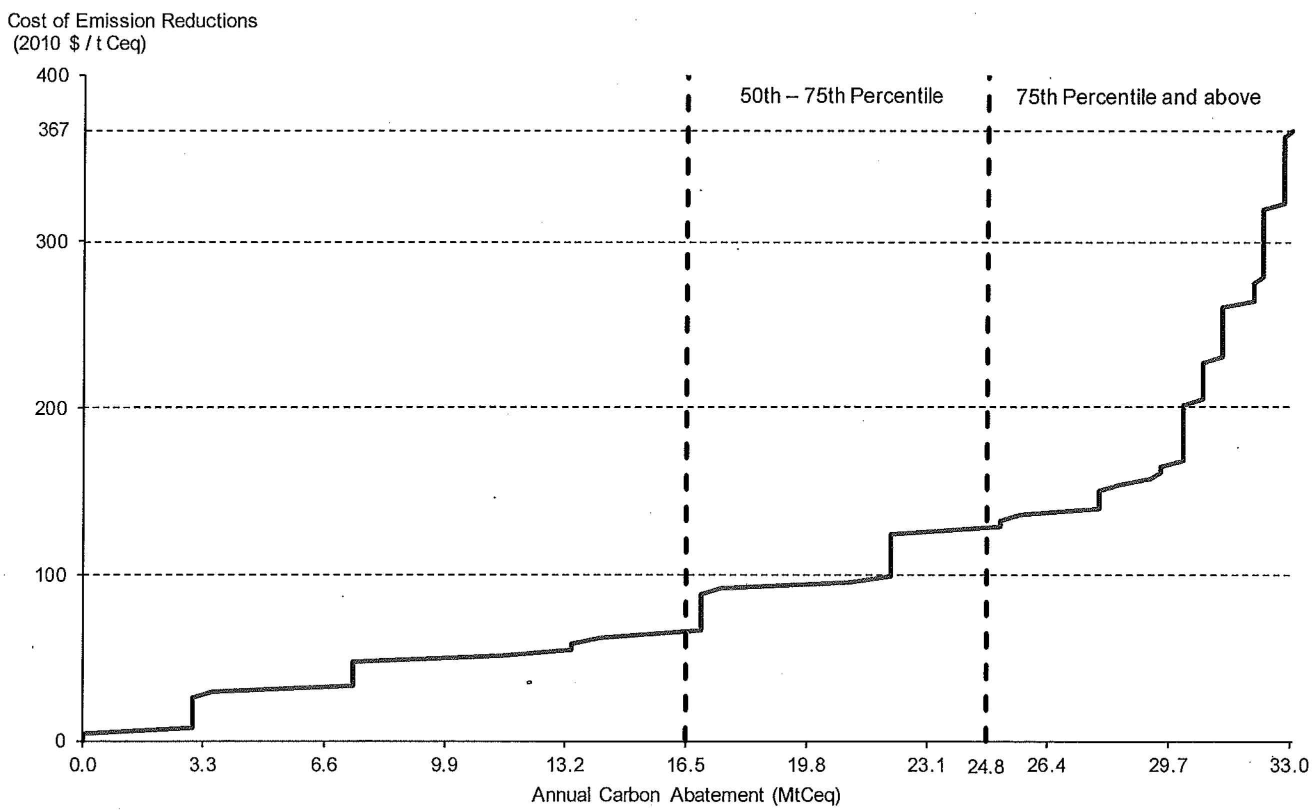
[35] I have recreated ICF's Figure 1 as shown on page 3 of the ICF 2016 Report by a manual inspection of the figure. Figure 2 only includes the abatement potential where the break-even price for a given method, farm, and crop combination was between $3.67 and $367 per ton of carbon.

44. ICF's data demonstrate that:

- Half of the potential GHG abatement provided by the agricultural management practices studied (16.5 of 33 MtCeq) could be realized at a cost of $66 per tCeq or less.
- An additional 8.3 MtC — i.e., an additional 25% — of potential abatement from these practices could be realized at a cost of $66 to $128 per tCeq.
- The final 25% of potential GHG abatement from these practices could be realized, but at costs ranging from $128 to $367 per tCeq.

Figure 2

ICF Marginal Abatement Costs, All Methods



Source: ICF 2016 Report

VI. Dr. Robertson Fails to Consider the Indirect Effects of Changes in Agricultural Methods

45. The preceding section reviewed evidence on the direct costs that farms would incur in adopting Dr. Robertson's proposed methods. In addition to these direct effects, Dr. Robertson's methods would also impose a number of indirect costs. I examine these effects in this section.

46. Dr. Robertson fails to account for the impact of his proposed methods on the cost and availability of food in the United States, on incomes and employment in rural communities, and on other valuable social priorities, including income and nutrition for low income populations in the United States and elsewhere, and environmental and conservation priorities other than GHG abatement. While these effects are not costs in the narrow sense, i.e., lost revenue or increased expenditures by growers that adopt Dr. Robertson's methods, they are indeed costs in the broad sense. Consumers in the U.S. and abroad are less well-off if they face higher food prices, and residents of the U.S. are less well off to the extent that they value environmental priorities (e.g., reduced herbicide use) compromised by adoption of Dr. Robertson's methods. Effects such as these should be accounted for in any analysis of the costs and benefits of Dr. Robertson's proposal. Finally, as I explain below, the abatement amount that Dr. Robertson claims may be offset by displacement of agricultural production from the U.S. to other countries with more GHG-intensive agricultural production. This too must be accounted for in analyzing Dr. Robertson's proposal.

A. Impact on food supply

47. Agricultural markets are global, and the United States is a large participant. Indeed, the United States is a critical supplier of food to the world as well as a large importer of food. U.S. farms supply nearly 25% of wheat, corn, and rice in global export markets.[36] The United States is an even more important supplier of soybeans and several tree crops.[37] As a result, substantial changes in U.S. agricultural practices would likely affect not only production and prices in the United States, but supplies and prices for food products worldwide. Dr. Robertson

[36] "Climate Impacts on Agriculture and Food Supply," *EPA*, undated, https://archive.epa.gov/epa/climate-impacts/climate-impacts-agriculture-and-food-supply.html, accessed August 3, 2018.

[37] See "Top U.S. Agricultural Exports in 2017," USDA, https://www.fas.usda.gov/data/top-us-agricultural-exports-2017, accessed August 12, 2018.

acknowledges these facts in his academic research,[38] and states explicitly that properly valuing environmental mitigation practices includes evaluating "what society (consumers) might be willing to pay through mechanisms such as higher food prices and taxes."[39] Despite this, in his report Dr. Robertson fails to account for the impact of his proposed methods on agricultural markets and the food system.

48. The academic literature establishes that Dr. Robertson's proposed methods may reduce yields (i.e., output per acre) for certain crops in certain regions. Basic economic principles and empirical evidence show that prices increase as yield (i.e., the supply of an agricultural product) declines.

49. The use of no-till farming methods is likely to reduce yields in some important circumstances. A review of 678 studies of no-till farming found that yields declined by 2.6% for wheat, 7.5% for rice, and 7.6% for maize relative to conventional tillage.[40] Another 2012 study, which Dr. Robertson cites, concludes that no-till farming reduces yields of winter wheat and corn in cooler, wetter climates, such as the Corn Belt, Great Lakes, and Mid-Atlantic regions of the United States.[41] Dr. Robertson acknowledges in his report that no-till methods reduce yields,[42] but fails to account for the cost of yield reductions arising from no-tillage. In one example, cotton farms in the Tennessee Valley region of northern Alabama in the early 1990s that adopted no-till methods found 8% to 15% yield reductions in cotton compared to conventional tillage.[43]

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[38] Alison J. Eagle et al., "Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature," Nicholas Institute for Environmental Policy Solutions: Duke University Third ed., 2012 ("Eagle et al. 2012"), pp. 1–76 at p. 4 ("Some management activities that mitigate greenhouse gases can significantly affect yield or production (e.g., fertilizer rate reductions, changes in crop mix and animal numbers), and the GHG impacts beyond the field or farm—or even beyond the country—will need to be considered in program or protocol development.").

[39] G. Philip Robertson et al., "Farming for Ecosystem Services: An Ecological Approach to Production Agriculture," in *The Ecology of Agricultural Landscapes: Long-Term Research on the Path to Sustainability*, ed. S. K. Hamilton et al. (New York: Oxford University Press, 2015), p. 34.

[40] Cameron M. Pittelkow et al., "When Does No-Till Yield More? A Global Meta-Analysis," *Field Crops Research* 183, 2015, pp. 156–168 at p. 156, https://www.sciencedirect.com/science/article/pii/S0378429015300228.

[41] Stephen M. Ogle et al., "No-Till Management Impacts on Crop Productivity, Carbon Input and Soil Carbon Sequestration," *Agriculture, Ecosystems and Environment* 149, 2012, pp. 37–49 at pp. 37–38, 41.

[42] Robertson Report, p. 11 ("[N]o till also has less capacity to increase soil carbon in cooler or wetter areas where it can sometimes reduce crop yield").

[43] E. B. Schwab et al., "Conservation Tillage Systems for Cotton in the Tennessee Valley," *Soil Science Society of America Journal* 66, no. 2, 2002, pp. 569–577 at p. 569. A later study found that the addition of rye cover crops with no-tillage prevents yield deceases.

50. Second, reductions in nitrogen fertilizer rates are likely to decrease yields in a substantial proportion of agricultural land. The ICF 2013 Report estimates that changes in fertilizer application rates could be adopted without decreasing yields in only 25% of corn cropland area and only 34% of wheat cropland area.[44] For example, annual corn production in the Northern Plains Region could decrease by 0.07 metric tons per acre in response to a 10% reduction in the nitrogen application rate.[45] In his report, Dr. Robertson recommends reducing nitrogen fertilizer usage to the rate necessary for an "optimum" yield.[46] However, in his academic research, Dr. Robertson explains that fertilizer rates needed for optimum yield depend on a myriad of variables that may change daily, making reliable recommendations inherently difficult.[47]

51. Fertilizer is a costly input, and farmers do not knowingly waste their scarce available funds to purchase fertilizer for which the expected gains are less than the costs. Of course, sometimes, however, the full *social* cost of fertilizer is higher than the cost the farmer pays because of water pollution impacts, local air quality impacts, or GHG emissions, for example. In all those cases, it may be wise government policy to encourage reductions in fertilizer use, but one cost of such policies will often be lower yields in most years.

52. Third, Dr. Robertson's proposed conversion of cropland to perennial grasses, whether for conservation reasons or to support cellulosic bioenergy, would remove land from agricultural production, reduce agricultural output, and thereby cause prices to increase. Dr. Robertson once again acknowledges this impact in his report, but he does not discuss or evaluate the trade-off between higher food prices and GHG abatement.[48]

53. The yield reductions noted above may displace agricultural production from the U.S. to other countries with more GHG-intensive agricultural production. Because the carbon intensity per unit of farm output is lower in the United States than in many other countries, displacement of agricultural production from the United States to other countries may result in a net increase in

[44] ICF 2013 Report, p. 2.22.

[45] ICF 2013 Report, p. 2.26.

[46] Robertson Report, p. 3.

[47] Adam Reimer et al., "Moving Toward Sustainable Farming Systems: Insights from Private and Public Sector Dialogues on Nitrogen Management," *Journal of Soil and Water Conservation* 72, no. 1, 2017, pp. 5A–9A at p. 6A. .

[48] Robertson Report, p. 14 ("Converting annual cropland to perennial grassland has no climate benefit where equivalent food production must be made up by more intensive crop production elsewhere.").

GHG emissions.[49] Indeed, Dr. Robertson cites one of his own academic research studies that makes precisely this point, noting that "the need to grow additional [crops] elsewhere (at perhaps lower efficiency) may more than offset any local mitigation gains."[50]

54. Dr. Robertson's proposed change to rice water management methods serves as an example. Rice yields in the United States are among the world's highest due in part to careful management of irrigation.[51] Changes to rice water management methods that increase costs and reduce yields would cause supplies to fall and rice prices to increase. This would affect global rice production because, while the United States accounts for less than 2% of world output, it is one of the top five exporters of rice, typically accounting for 10% to 12% of world exports.[52] To the extent that countries with more GHG-intensive production methods replace the supply of U.S.-grown rice, on a net basis GHG emissions may increase. Moreover, an increase in rice prices globally could affect the ability of the most vulnerable populations (i.e., those who receive emergency food aid from organizations like the World Food Programme) to obtain food.[53]

B. Ecological and social tradeoffs

55. In his report —in contrast to his academic research—Dr. Robertson fails to acknowledge the existence of tradeoffs between GHG abatement and environmental effects arising from the adoption of his proposed methods.

56. There are natural environmental costs and ecological consequences associated with Dr. Robertson's proposed methods. For example, Dr. Robertson acknowledges in his own academic research that reduced tilling could increase herbicide use, and notes that such an understanding

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[49] "New Data on Greenhouse Gas Emissions Intensities," Food and Agriculture Organization of the United Nations, http://www.fao.org/economic/ess/environment/ghgintensities/en/.

[50] Eagle et al. 2012, p. 35. See also Robertson Report, p. 14 ("Nevertheless, such conversions must be planned carefully to result in a legitimate climate benefit: Converting annual cropland to perennial grassland has no climate benefit where equivalent food production must be made up by more intensive crop production elsewhere, especially if such displaced crop production causes deforestation.").

[51] David Dawe ed., *The Rice Crisis: Markets, Policies and Food Security* (Earthscan, 2010), p. 315, http://www.fao.org/3/a-an794e.pdf.

[52] David Dawe ed., *The Rice Crisis: Markets, Policies and Food Security* (Earthscan, 2010), p. 315, http://www.fao.org/3/a-an794e.pdf.

[53] "Cheap No More," *The Economist*, December 6, 2007, https://www.economist.com/briefing/2007/12/06/cheap-no-more.

of the tradeoffs and synergies are typically absent from agricultural research.[54] Moreover, Dr. Robertson acknowledges in his report that summer fallow cannot be used every year where it is used for water conservation.[55]

57. Manure digesters provide another example of the tradeoff between GHG abatement and other environmental objectives. Manure digesters are used in animal production to convert methane from anaerobic decomposition of cattle manure into fuel for electricity generation.[56] Methane is a potent greenhouse gas.[57] However, the methane conversion process generates nitrous oxide ("NOx") emissions unless costly equipment is used.[58] In regions that violate Federal air quality standards, such as the Central Valley of California, the most dairy intensive region in the United States,[59] NOx pollution from digesters would add substantially to the full social cost of using this methane reduction method to mitigate GHG emissions.[60,61]

58. Carbon sequestration programs in forests can also require tradeoffs against other environmental costs. Academic studies have shown that if the marginal value of carbon

[54] G. Philip Robertson et al., "Farming for Ecosystem Services: An Ecological Approach to Production Agriculture," in *The Ecology of Agricultural Landscapes: Long-Term Research on the Path to Sustainability*, ed. S. K. Hamilton et al. (New York: Oxford University Press, 2015), p. 34 ("Knowledge of the services themselves requires a fundamental understanding not only of the biophysical basis for the service but also of how different ecological processes interact to either synergize or offset the provisioning of different services: Farming is a systems enterprise with multiple moving parts and sometimes complex interactions. No-till practices, for example, can sequester soil carbon and reduce fossil fuel consumption but require more herbicide use and can increase the production of nitrous oxide (N_2O; van Kessel et al. 2013), a potent greenhouse gas. Understanding the basis for such trade-offs and synergies requires an ecological systems approach absent from most agricultural research.").

[55] Robertson Report, p. 12, ("Where summer fallow is used for water conservation, summer fallow cannot likely be eliminated.").

[56] John Stumbos, "Methane Generators Turn Agricultural Waste Into Energy," *California Agriculture* 55, no. 5, 2001, pp. 8–9. See also P. Lusk, "Methane Recovery from Animal Manures: The Current Opportunities Casebook," NREL Report SR-580-25145, September 1998, p. 2-11, 2-18.

[57] Pound for pound, the impact of CH4 is more than 25 times greater than CO2 over a 100-year period. See "Overview of Greenhouse Gases," *EPA*, https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

[58] With respect to compliance with nutrient management plans USDA found that "Farmers who produce electricity through digesters can benefit from avoided purchases of electricity, but few can realize enough savings to justify the expense." See "Manure Use for Fertilizer and for Energy," USDA Report to Congress, June 2009. p. 41.

[59] "California Dairy Review" Volume 22, Issue 7, July 2018. https://www.cdfa.ca.gov/dairy/uploader/docs/CDR%20JUL%2018.pdf

[60] P. Lusk, "Methane Recovery from Animal Manures: The Current Opportunities Casebook," NREL Report SR-580-25145, September 1998, pp. 3-5, 3-15.

[61] J. Hower and D. S. Chianese, "Digester Gas Combustion," Got Manure Conference Presentation, 2012, p.1, ("[C]ombusting biogas can also result in issues different from those encountered when combusting natural gas, among them changes in emissions, difficulties meeting required emission standards, and capital costs required to comply with regulations.").

emission reductions to society is chosen inappropriately for the projects being evaluated, over-harvesting or severe under-harvesting can occur.[62] This could decrease the supply of lumber in the market and cause a divergence from what may be environmentally optimal. Another result can be the increase in susceptibility to fire damage that can have large social, human health and economic consequences.[63] Additionally, another study found that flawed carbon compensation policy "may create unintended incentives to excessively harvest existing forests if only regenerated forests qualify for carbon credits."[64]

59. As reinforcement of the need to evaluate tradeoffs, a special issue from the 4th USDA Greenhouse Gas Symposium states that "technologies and science have to be linked with public policy to evaluate the economics and social implications of different emission scenarios and technologies."[65] Dr. Robertson has failed to do so in his report.

VII. Dr. Robertson Overstates the Amount of GHG Abatement His Proposed Methods Would Yield

60. It is unlikely that Dr. Robertson's proposed methods, if implemented, would yield the amount of GHG abatement that Dr. Robertson claims in his report. Government research and academic research, some of it conducted by Dr. Robertson, demonstrates that some of his

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[62] G. Cornelius Van Kooten et al., "Effect of Carbon Taxes and Subsidies on Optimal Forest Rotation Age and Supply of Carbon Services," *American Journal of Agriculture Economics* 77, 1995, pp. 365–374 at p. 372 ("[I]n some circumstances, once carbon uptake services are appropriately accounted for, it may not be worthwhile to harvest old-growth forests or even planted forests.").

[63] Matthew D. Hurteau et al., "Carbon Protection and Fire Risk Reduction: Toward a Full Accounting of Forest Carbon Offsets," *Frontiers in Ecology and the Environment* 6(9), November 2008, pp. 493–498 at p. 493 ("Management of forests for carbon uptake is an important tool in the effort to slow the increase in atmospheric CO2 and global warming. However, some current policies governing forest carbon credits actually promote avoidable CO2 release and punish actions that would increase long-term carbon storage. In fire-prone forests, management that reduces the risk of catastrophic carbon release resulting from stand-replacing wild fire is considered to be a CO2 source, according to current accounting practices, even though such management may actually increase long-term carbon storage. Examining four of the largest wildfires in the US in 2002, we found that, for forest land that experienced catastrophic stand-replacing fire, prior thinning would have reduced CO2 release from live tree biomass by as much as 98%. Altering carbon accounting practices for forests that have historically experienced frequent, low-severity fire could provide an incentive for forest managers to reduce the risk of catastrophic fire and associated large carbon release events.") See also Michael A. Toman and P. Mark S. Ashton. "Sustainable Forest Ecosystems and Management: A Review Article," *Forest Science* 42(3), 1996, pp. 366–377.

[64] Brian C. Murray, "Carbon Values, Reforestation, and 'Perverse' Incentives Under the Kyoto Protocol: An Empirical Analysis," *Mitigation and Adaptation Strategies for Global Change* 5, 2000, pp. 271–295 at p. 271.

[65] See Jerry L. Hatfield, "Special Issue from the 4th USDA Greenhouse Gas Symposium," *Journal of Environmental Quality*, 2008, https://dl.sciencesocieties.org/cache/publications/abstract-preview/jeq-37-4-1317-preview-1000.png, accessed August 3, 2018.

proposed methods are not technically viable; that others are not economically viable; and that for others, an abatement amount cannot be reliably estimated. The GHG abatement amounts from methods that fall into these categories comprise approximately half of the total abatement that Dr. Robertson reports. Moreover, research commissioned by USDA suggests that, even after correcting for these issues, Dr. Robertson's conclusion as to potential abatement is implausibly large.

A. Dr. Robertson includes methods that are not technically viable

61. Dr. Robertson's conclusion that his proposed methods would yield approximately 31 GtCeq of GHG abatement from 2020 to 2100 rests on the assumption that each of his proposed methods is technically viable, and the further assumption that each of his proposed methods would yield the GHG abatement amounts that he describes.

62. Closer examination demonstrates that these assumptions are not correct. As I explain in this section, the research for some of Dr. Robertson's proposed methods (some of it published by Dr. Robertson himself) does not establish that the methods are technically viable, or that the methods would in fact provide the promised amount of GHG abatement set forth in Dr. Robertson's Table 2. Indeed, Dr. Robertson concedes that the GHG abatement amounts set forth in his report may overstate actual amounts by as much as 30%.[66]

63. Academic research does not confirm to a reasonable degree of certainty that for purposes of setting agricultural policy, Dr. Robertson's proposed methods are technically viable and will yield the amount of abatement shown in his Table 2. For example, Dr. Robertson acknowledges in his publications that research for certain methods suffers from "data gaps" and is "insufficient to support broad protocol or program development"[67] for a number of the methods proposed in his report. These methods include winter cover crops, crop rotation diversification, and wetland restoration.[68] As shown in Figure 3, these practices account for 10% of the GHG abatement amount estimated in Dr. Robertson's report.

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[66] Robertson Report, p. 26: "The values in Table 2 are, in general, conservative …. Further research will lead to their refinement, but it seems unlikely that average values will change more than 20-30%." Dr. Robertson further claims that "values are in any case as likely to increase in magnitude as to decrease."

[67] Eagle et al. 2012, p. 56.

[68] Eagle et al. 2012, p. 56 ("A few management practices on this early-action list have high mitigation potential but significant data gaps (data is lacking for some regions or some conditions have been unstudied). These activities—

Figure 3

Dr. Robertson's Proposed Methods and Claimed GHG Abatement

Proposed Method	Robertson Report: Total Abatement as of 2100 (GtCeq)	Robertson Report: Percent of Total	Unlikely to Yield Claimed GHG Abatement[1]
Negative emissions			
Cropland management			
No till adoption	1.13	3.7%	
Reduced summer fallow	0.05	0.2%	√
Winter cover crops	2.75	9.0%	√
Diversified crop rotations	0.18	0.6%	√
Manure & compost additions	0.48	1.6%	
Cropland conversion to perennial grasses			
Set-aside highly erodible cropland	0.76	2.5%	
Cellulosic bioenergy on grain ethanol lands	0.38	1.2%	√
Cellulosic bioenergy on marginal lands	0.79	2.6%	√
Grazing land management			
Improved stocking rates on rangeland	4.84	15.8%	√
Improved species composition	1.34	4.4%	
Wetland histosol restoration	0.23	0.8%	
Forest management			
Improved soil management – timberland	4.10	13.4%	
Improved soil management – agroforestry	1.13	3.7%	
Improved stand management	2.75	9.0%	
Subtotal – Negative emissions	**20.9**	**68.3%**	
Avoided emissions			
Improved fertilizer efficiency			
Avoided nitrous oxide emissions	3.60	11.8%	
Avoided CO2 – fertilizer production	0.35	1.1%	
Rice water management for methane	0.06	0.2%	
Cellulosic bioenergy production			
Production on grain ethanol lands	0.97	3.2%	√
Production on marginal lands	4.75	15.5%	√
Subtotal – Avoided emissions	**9.70**	**31.7%**	
Total potential	**30.6**	**100.0%**	**48.1%**

Source: Robertson Report, Table 2; ICF 2013 Report; ICF 2016 Report

Note:
[1] Methods are marked as unlikely to yield claimed GHG abatement either because they are technically and economically unfeasible (cellulosic bioenergy), because they were deemed economically unfeasible in ICF's analysis (reduced summer fallow, winter cover crops, and diversified crop rotations), or because ICF concluded that an abatement amount could not be reliably estimated (improved stocking rates on rangeland). Note that ICF did not analyze many of the methods that Dr. Robertson proposes. That a proposed method is not identified as unlikely to yield Dr. Robertson's claimed GHG abatement is not an affirmation of Dr. Robertson's conclusion.

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use of winter cover crops, various N [nitrogen] management practices, conservation tillage, *and crop rotation diversification*—are recommended as top research priorities. Eight of the remaining activities appear to have positive GHG mitigation potential, but the existing research is insufficient to support broad protocol or program development. These activities—*histosol management* or set aside, crop rotation intensification, irrigation management, agroforestry on cropland or pasture, manure management for N2O emissions reduction, and rotational grazing on pasture—warrant research to clarify GHG and other implications." (Emphasis Added)).

B. Cellulosic bioenergy is manifestly not technically viable

64. Dr. Robertson has also concluded in his academic work that another of his proposed GHG abatement methods, cellulosic bioenergy, is not technically viable.[69] A presentation that Dr. Robertson delivered at a recent academic conference notes that "most of what we think we know about net GHG mitigation from cellulosic bioenergy has come from modeling studies" rather than empirical fieldwork; that recent research reveals "important knowledge gaps;" that "the devil is in the details;" and that the details "substantially affect the delivery of net climate benefits."[70]

65. Further, the scale at which Dr. Robertson proposes to adopt cellulosic bioenergy is demonstrably unfeasible. Efforts over the last decade to develop cellulosic bioenergy at a commercial scale in the U.S. have largely failed. Congress mandated the use of advanced biofuels (whose main component is cellulosic ethanol) under the Renewable Fuel Standard ("RFS") law included in 2007 energy legislation; the law required oil refiners and gasoline importers to meet minimum targets for the use of biofuels in gasoline.[71] Despite years of subsidy, mandates, and federal and private research and development efforts, production of advanced biofuels has not come close to the mandated targets due extremely high production

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[69] G. Philip Robertson et al., "Cellulosic Biofuel Contributions to a Sustainable Energy Future: Choices and Outcomes," *Science* 356, 2017, pp. 1–9 at 1 ("Many questions about cellulosic biofuel sustainability remain. Still needed is an integrated understanding of the entire field-to-product enterprise sufficient to leverage synergies and to avoid trade-offs that can diminish environmental benefits.").

[70] "Practices Effect on Greenhouse Gas Emissions, Mitigation Strategies, and Modeling," *American Society of Agronomy*, 2017, https://scisoc.confex.com/crops/2017am/webprogram/Paper108621.html, accessed August 7, 2018 ("Lignocellulosic bioenergy offers substantial potential for greenhouse gas mitigation but the *devil is in the details: prior land use, crop choice, and management decisions substantially affect the delivery of net climate benefits. Few empirical studies have addressed the impact of these decisions: most of what we think we know about net GHG mitigation from cellulosic bioenergy has come from modeling studies*. Consequently many agronomic challenges remain. Nevertheless, recent experimental results are sufficient to suggest guiding principles for practice and policy and *to reveal important knowledge gaps that deserve the research community's attention*. Guiding principles and knowledge gaps will be presented in the context of research that has revealed both the potentials and pitfalls of current cellulosic bioenergy cropping systems." (Emphasis Added)).

[71] The Renewable Fuel Standard ("RFS") as first enacted by Congress in the Energy Policy Act of 2005 required that oil refiners and gasoline importers subject to the legislation meet targets for the use of biofuels in gasoline. See "United States Government Accountability Office Report, "Renewable Fuel Standard: Program Unlikely to Meet Its Targets for Reducing Greenhouse Gas Emissions," November 2016 ("GAO Report"), https://www.gao.gov/assets/690/681252.pdf, p. 3. Congress amended the RFS in 2007 to include targets for the use of "advanced biofuels," including ethanol derived from cellulose, sugar, or waste material. See GAO Report, pp. 3-5.

costs.[72] Recent research concludes that the production of cellulosic ethanol "is only in an experimental stage in the United States," and that facilities for the commercial production of cellulosic bioenergy in the United States are very limited in number.[73]

66. As shown in Figure 3, cellulosic bioenergy accounts for 23% of the abatement amount claimed in Dr. Robertson's report.

67. The advanced biofuel targets in the RFS had a number of unintended consequences. Many academic studies have found that the RFS has had an adverse impact on food prices and poverty, and has caused a net increase in GHG emissions due to land use changes.[74]

68. The use of the RFS to spur adoption of advanced biofuels is a clear-cut and instructive example of the risks of implementing policy before thoroughly assessing the underlying costs and benefits. Upon implementation, well-intentioned policy uninformed by analysis of costs and benefits can become economically wasteful and a poor use of scarce resources. The same risks apply to Dr. Robertson's proposal. Implementation of Dr. Robertson's proposed methods without an evaluation of costs would likely waste social resources and under some circumstances could increase GHG emissions.

[72] "GAO Report, pp. 10–11 ("The shortfall of advanced biofuels is the result of high production costs, despite years of federal and private research and development efforts. The RFS was designed to bring about reductions in greenhouse gas emissions by blending targeted volumes of advanced and, in particular, cellulosic, biofuels, because those fuels achieve greater greenhouse gas reductions than conventional corn-starch ethanol and petroleum-based fuel. However, because advanced biofuel production is not meeting the RFS's targets, the RFS is limited in its ability to meet its greenhouse gas reduction goals as envisioned. According to several experts we interviewed, the investments and development required to make these fuels more cost-effective, even in the longer run, are unlikely in the current investment climate, in part because of the magnitude of investment and the expected long time frames required to make advanced biofuels cost-competitive with petroleum-based fuels.").

[73] "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2016," EPA Report 430-R-18-003, April 12, 2018, p. 7-27; Lee R. Lynd et al., "Cellulosic Ethanol: Status and Innovation," *Current Opinion in Biotechnology* 45, 2017, pp. 202–211.

[74] Harry de Gorter and David R. Just, "The Social Costs and Benefits of Biofuels: The Intersection of Environmental, Energy and Agricultural Policy," *Applied Economic Perspectives and Policy* 32, no. 1, 2010, pp. 4–32 at p. 5 ("Some studies argue that ethanol policies fail to pass an overall cost-benefit test, that they have an adverse impact on food prices and poverty—especially in developing countries and create higher greenhouse gas emissions due to indirect land use changes.") (Internal citations omitted). Colin A. Carter et al., "Commodity Storage and the Market Effects of Biofuel Policies," *American Journal of Agricultural Economics* 99(4), March 15, 2016, pp. 1027–1055.

C. Dr. Robertson appears to overstate the sequestration rate and scale of adoption for his proposed methods

69. Dr. Robertson's conclusion as to the total annual GHG abatement his proposed methods would yield depends on assumptions as to abatement rates and the land area over which his proposed methods can be applied.[75] Evidence from other research suggests that Dr. Robertson's assumptions in his report are optimistic and that he misuses results reported in the academic literature (including his own publications) as to the sequestration rate and the land area over which his proposed methods would be applied.

1. Dr. Robertson's GHG abatement rates and total land area values are larger than those reported by ICF

70. For the two agricultural methods studied by both Dr. Robertson and ICF (no-tillage farming and reduced fertilizer usage), Dr. Robertson assumes GHG abatement rates considerably higher than the rates used by ICF.[76]

- For no-tillage adoption, Dr. Robertson assumed an abatement rate of 0.40 tCeq while ICF estimated an abatement rate of 0.25 tCeq.
- For reduced fertilizer usage, Dr. Robertson assumed an abatement rate of 0.36 tCeq while ICF estimated an abatement rate of 0.058 tCeq.

71. Similarly, Dr. Robertson assumes a land area for use of no-tillage and reduced fertilizer usage far larger than the value ICF reports.[77]

- For no-tillage adoption, Dr. Robertson assumes a land area of 94.0 Mha while ICF estimates a land area of 38.3 Mha.
- For reduced fertilizer usage, Dr. Robertson assumes a land area of 125.0 Mha while ICF estimates a land area of 61.6 Mha.

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[75] Dr. Robertson computes annual abatement as the product of abatement rate per unit land area and land area. For example, as shown in Table 2, Dr. Robertson calculates a total annual GHG abatement for no-till adoption of 37.6 MtCeq. This is calculated as the product of the no-till rate (.40 tCeq) and the total land areas 94 Mha.

[76] Robertson Report, Table 2. ICF abatement rates are calculated using the data provided in the ICF 2013 Report.

[77] Robertson Report, Table 2. ICF total land area for each method is calculated using the data provided in the ICF 2013 Report.

72. These differences explain the dramatic difference in potential abatement that Dr. Robertson reports for as compared to ICF. As noted previously, the amount of abatement potentially available from these methods according to Dr. Robertson's Table 2 is more than six times the amount estimated by ICF.

2. Dr. Robertson overstates the land area to which his proposed methods would be applied

73. In his Table 2, Dr. Robertson makes assumptions as to the land area to which each of his proposed methods would be applied. Comparison of his report assumptions to values reported in the academic literature, including his own research publications, demonstrates that Dr. Robertson misuses results reported in the academic literature for purposes of the analysis in his report.

74. For example, Dr. Robertson relies on a 2012 paper he co-authored ("Eagle et al.") as the basis for land area estimates for eight of his proposed methods.[78] In each instance, he assumes that his proposed method from his Table 2 would be applied over the maximum potential land area reported in the Eagle et al. study. In so doing, he ignores the explicit caution set forth in the study that use of the maximum value is likely unreliable. The Eagle et al. study explicitly states that:

> "The maximum applicable land area for the mitigation activities assessed here (over and above current adoption rates, i.e., baseline area) was also determined from the literature and available survey data. … Because multiple activities may compete for the same land area, *the practical area available for implementation will likely be lower, at least for the activities that are more expensive or challenging to adopt. More detailed economic land-use competition analysis and an assessment of interactions among activities are needed for any national predictions of total mitigation potential.*"[79]

75. Dr. Robertson does not explain why the land area assumptions in his report are reliable despite explicit statements in his own academic publications that these assumptions likely

[78] Eagle et al. 2012. Dr. Robertson is a co-author of this paper. The eight methods include no-tillage, reduced summer fallow, winter cover crops, diversified crop rotations, manure and compost additions, grazing-improved species composition, wetland restoration, and rice water management. Robertson Report, Table 2.

[79] Eagle et al. 2012, p. 4. Emphasis added.

overstate the "practical area available for implementation" and that they are not a reliable basis for "any national predictions of total mitigation potential."

76. Dr. Robertson also appears to ignore warnings and caveats in the academic literature in his assumptions as to the area over which grazing management could be applied. The study that Dr. Robertson cites as a foundation explicitly states that (i) the land in the study was selected precisely because researchers expected that the methods under study would show abatement results on this land; (ii) the abatement results reported in the paper "do not apply uniformly to all grazing lands," and should not be extrapolated regionally or globally; and (iii) in some circumstances, grazing management methods will not yield any abatement benefits.[80] Despite these clear warnings, Dr. Robertson assumes that the sequestration rate reported in the study can be projected to almost all grazing grassland and pasture land in the U.S.

D. Dr. Robertson's abatement total assumes GHG abatement from methods that ICF deems economically unfeasible

77. Dr. Robertson's abatement conclusion includes abatement from three crop production methods that ICF deemed economically unfeasible and abatement from a grazing management method whose abatement yield cannot be reliably estimated.

78. ICF examined five of the agricultural methods that appear in Dr. Robertson's report, and concluded that three crop production methods —diversifying crop rotation, winter cover crops, and reducing summer fallow—were "unlikely to be widely adopted in response to a GHG mitigation incentive."[81] More specifically, ICF concluded that costs associated with use of these

[80] Richard T. Conant et al., "Grassland Management Impacts on Soil Carbon Stocks: A New Synthesis," *Ecological Applications* 27, no. 2, 2017, pp. 662–668 at p. 666 ("each of these grazing studies investigated the impacts of a specific grazing management intervention under conditions in which the implemented change in grazing management was warranted and expected to be beneficial. Thus these results do not apply uniformly to all grazing lands and extrapolating the results of this synthesis regionally or globally requires information about where there is scope for improvement of grassland management…."[I]t is not always the case that improved grazing management leads to increased soil [carbon sequestration]").

[81] ICF 2013 Report, p. 2.18.

methods were "prohibitively high" in some settings or negative in others.[82,83] ICF does not formally define "prohibitively high,"[84] but I note that ICF does not report abatement benefits for methods for which the marginal abatement cost (i.e., the carbon price) exceeds $367 / tCeq.[85] As shown in Figure 3 these three methods account for approximately 10% of the total GHG abatement benefit that Dr. Robertson claims to offer.

79. Further, ICF did not estimate marginal abatement costs for a grazing management method ("improved stocking rates on rangeland") that contributes one of the largest amounts of annual and cumulative abatement in Dr. Robertson's analysis. ICF concluded that it could not reliably estimate costs and abatement benefits for grazing management because the abatement benefits are highly dependent on local conditions.[86] Academic research that Dr. Robertson relies upon as to the abatement benefits of grazing management methods reaches the same conclusion.[87] As shown in Figure 3, this grazing method accounts for approximately 16% of the total GHG abatement benefit that Dr. Robertson claims his proposed methods will yield.

E. Dr. Robertson's Overstatement of GHG Abatement

80. The discussion above demonstrates that Dr. Robertson overstates the amount of GHG abatement that his proposed methods would provide if adopted on the scale that he assumes. Figure 3 shows that the amount of GHG abatement from Dr. Robertson's proposed methods falls by nearly half if we exclude the abatement amounts that Dr. Robertson assumes for (i) cellulosic

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[82] ICF 2013 Report, p. 2.17–2.18 ("Eliminating fallow is problematic as it is essential in some cases for increasing soil moisture and maintaining soil quality. Consequently, this type of crop rotation will only be applicable to limited land areas. Eliminating fallow will obviously be cost-effective over the short term for a landowner as he or she will receive additional crop revenue. In this situation, an incentive would not be needed for eliminating fallow (i.e., the break-even price would be negative). Planting an alternative crop will likely result in a loss of revenue and, hence, will be a barrier to adoption as landowners would need to transition from the optimal crop for their regional market, climate, and soil conditions. In addition, planting a cover crop will not compensate for the decrease in revenue from more profitable crops (e.g., cotton revenue in a cotton-to-cover crop rotation). Consequently, rotations involving the planting of an alternative crop would likely result in a prohibitively high break-even price.").

[83] ICF based its opinion on net GHG impact of crop rotation data from the U.S. National Inventory of GHG Emissions and Sinks and other sources as reported by the Greenhouse Gas Working Group (2010) cited in Ogle (2011b).

[84] ICF 2016 Report, p. 3 ("For each mitigation option considered in this analysis, there are farms that … would require a prohibitively high CO2 price (e.g., over $40 per mt CO2e).").

[85] See ICF 2016 Report, Figure 1, p. 3.

[86] See ICF 2016 Report, p. 41.

[87] Richard T. Conant et al., "Grassland Management Impacts on Soil Carbon Stocks: A New Synthesis," *Ecological Applications* 27, no. 2, 2017, pp. 662–668.

biofuel, which is not technically viable; (ii) crop production methods that ICF deems economically unfeasible due to "prohibitively high" or negative marginal abatement costs (reduced summer fallow, winter cover crops, and diversified crop rotation); and (iii) improved stocking rates, a grazing management method for which abatement yield cannot be reliably estimated, according to ICF. These methods account for 14.7 GtCeq of GHG abatement, or 48% of the 30.6 GtCeq that Dr. Robertson claims.

81. Further, the ICF 2016 report taken as a whole strongly suggests that Dr. Robertson has overstated the amount of abatement that his proposed methods would yield. As noted in Section V, both ICF and Dr. Robertson respond to the same question, namely, what are the GHG abatement benefits that can be realized from changes in agricultural and land management practices in the U.S.?[88] Dr. Robertson's conclusion as to the potential amount of annual GHG abatement (535 MtCeq) is *sixteen* times larger than ICF's estimate (33 MtCeq).

82. This difference is due in part to Dr. Robertson's reliance on methods not included in ICF's analysis (i.e., cellulosic biofuel, which is not technically viable, and methods that ICF deems unreliable or economically unfeasible). However, an adjusted comparison leads to the same conclusion. I remove from ICF's estimate the abatement amount associated with animal production, which Dr. Robertson does not consider, and I remove from Dr. Robertson's estimate the abatement amounts for the methods noted above (all cellulosic biofuel methods, reduced summer fallow, winter cover crops, crop rotation, and improved stocking rates). Adjusted annual abatement for Dr. Robertson is 281.2 MtCeq, over ten times the size of the adjusted annual abatement for ICF (26.2 MtCeq).[89]

VIII. Plaintiffs' Criticism of U.S. Agricultural Policy Misunderstands the Policymaking Process

83. Plaintiffs allege that the USDA "contributes to a dangerous climate system" through its alleged support for "polluting farming and agricultural practices."[90] Plaintiffs have failed to

[88] The comparison between Dr. Robertson and ICF is based on annual abatement rather than cumulative abatement. ICF does not report estimates of cumulative abatement.

[89] See Robertson Report, Table 2. See also ICF 2016 Report, p. 17, noting that total annual abatement from methods applied to animal production is 6.5MtCeq.

[90] Complaint, ¶117.

recognize three important considerations. First, government policy makers must balance multiple policy objectives that often conflict. Second, government policy makers have taken affirmative steps to encourage the adoption of GHG abatement, either through government-funded programs or supporting research that will aid in achieving GHG abatement. Third, where government policy makers have not, or could not, given legal requirements, mandate or induce the adoption of certain practices, it was often due to the scientific evidence of the claimed effect being unreliable or because a cost-effective policy to cause adoption of the practice does not exist.

A. Government policy makers balance multiple, competing objectives

84. Government policymakers rightly must balance competing priorities. These priorities include food security (food price and food safety), economic security in the agricultural sector (e.g., farm income, price stability, productivity, and global competitiveness), and environmental conservation, such as reducing soil erosion and water and air pollution. These priorities are necessarily broader than eliminating or reducing GHG emissions. This theme emerges clearly in the mission statement set forth in the USDA's 2018 Strategic Plan, which states that the USDA will "promote the ability of America's agricultural sector to produce and sell the food and fiber that feeds and clothes the world," will "work to manage the natural resources entrusted directly to the Department—including our National Forests—with a sharp focus on the sustainable use of these resources," and will "provide all Americans access to a safe, nutritious, and secure food supply."[91] Academic studies of the history and practice of U.S. agricultural policy identify the same set of priorities.[92]

85. The priorities that inform U.S. agricultural and land use policy often conflict. For example, methods and practices that sequester carbon or mitigate GHG emissions may also reduce crop yields and cause farm costs and food prices to increase, which may compromise policy goals related to farm income and food security and lower real incomes of low income

[91] "USDA Strategic Plan: FY 2018 – 2022," *USDA*, May 2018, pp. 2, 53, https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf.

[92] Parke Wilde notes that USDA's goals for sustainable agriculture include "satisfying human food, feed, and fiber needs, and contributing to biofuel needs, enhancing environmental quality and the resource base, sustaining the economic viability of agriculture, and improving the quality of life for farmers, farm workers and society as a whole." See Parke Wilde, Food Policy in the United States: An Introduction (Abingdon, UK: Routledge, 2013), p. 35.

populations. Similarly, methods and practices that sequester carbon or mitigate GHG emissions may limit progress toward other conservation objectives. As a result, the USDA and other federal agencies must balance competing priorities.

86. For example, National Resources Conservation Service ("NRCS"), an agency of the USDA, provides technical assistance to farmers and landowners to conserve the nation's soil, water, air, and other natural resources. To help address potential tradeoffs, it has developed a conservation practices "physical effects" template that is designed to help participants understand how the implementation of a given practice would affect other resources, including soil erosion, excess or insufficient water, water quality degradation, air quality impacts, fish and wildlife habitats, and livestock production limitation.[93]

87. Similarly, academic studies have documented examples of tradeoffs that exist within farm and food policy, such as the tension between food safety and environmental and ecological goals.[94]

88. Agricultural policy and the multiple issues that arise in this context are not unique to the United States. Other countries also seek to balance priorities such as food security and other social, economic, and environmental objectives when considering the impact of agricultural policy on climate change. For example, in France, the "4 per mille" initiative, which seeks to encourage adoption of soil management practices that increase carbon sequestration, balances carbon sequestration against other priorities, including human rights, land rights, income distribution, food security, and other "social, economic, or environmental dimensions."[95]

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[93] By way of example, the NRCS publishes a workbook on its website that documents the conflicts between use of a land management practice and the effects on other conservation efforts. For example, within the workbook no-till is shown to have various positive and negative effects. Negative effects of no-till include a "Slight Worsening" effect on both "excess water" and "Excess Nutrients in Surface and Groundwater." See CPPE National.xlsm, https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/tools/?cid=nrcs143_009740.

[94] Parke Wilde, Food Policy in the United States: An Introduction (Abingdon, UK: Routledge, 2013), p. 115 ("[S]ome policy dilemmas pit food safety goals against other public interest objectives, not only against economic considerations. For example: (a) production standards for spinach farmers must balance food safety with environmental and ecological goals…; (b) dietary guidance about fruits and vegetables must balance nutritional advantages against safety risks from pesticides; and (c) FDA rules for very small producers and farmers' market vendors must balance consumer safety concerns against the goal of promoting local food systems.").

[95] "The 4 Per 1000 Initiative in a Few Words," 4p1000.org, https://www.4p1000.org/4-1000-initiative-few-words; "Reference Criteria and Indicators for Project Assessment," Proposal from the Scientific and Technical Committee of the 4 per 1000 Initiative, undated, https://www.4p1000.org/sites/default/files/content/gov_cst_en_4p1000_indicators_05-12-2017-final2.pdf. The French "4 per mille" initiative was launched on December 1, 2015 with the global goal to increase the soil carbon

B. U.S. agriculture and forestry policy supports GHG mitigation and sequestration efforts

89. Plaintiffs' criticism of Defendants' agricultural and forestry policies overlooks the fact that government policy makers have taken affirmative steps to encourage the adoption of agricultural and forestry practices that mitigate GHG emissions or sequester carbon, including funding research on practices that may contribute to future GHG abatement.

90. In fact, President Bush in 2002 requested that the USDA "look for ways to increase the amount of carbon stored by America's farms and forests through a strong conservation title in the farm bill."[96] The USDA has taken a series of actions. In particular, the USDA stated that it would "provide incentives and support voluntary actions by private landowners, including farmers and forest and grazing landowners."[97] Actions to be implemented by the USDA included "financial incentives, technical assistance, demonstrations, pilot programs, education and capacity building, along with measurements to assess the success of these efforts."[98] As I detail below, such actions had observable impacts.

91. The USDA has had a mandate since at least 2008 under the Food, Conservation, and Energy Act of 2008 to examine GHG abatement methods in farming and forestry,[99] and in 2010 adopted as a strategic goal providing "technical and financial assistance to farmers, ranchers, and forest landowners to implement conservation, nutrient management, and animal management practices that reduce emissions and sequester carbon."[100] Government policy makers have

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level by 0.4% a year equivalent to sequestration rates of 3.4 GtCeq, which would stop the increase in the CO2 concentration in the atmosphere related to human activities. The initiative has three aims: combating land degradation, participating in the goal of food security, and adapting agriculture to climate change. It is a voluntary program in which both the public sector (national, local, and regional governments) and the private sector (companies, trade organizations, research facilities, etc.) participate. "See "Welcome to the '4 per 1000' Initiative," 4p1000.org, https://www.4p1000.org/. See also Robertson Report, p. 24.

[96] "USDA Targeted Incentives for Greenhouse Gas Sequestration," USDA Fact Sheet, June 6, 2003, https://2001-2009.state.gov/g/oes/rls/fs/2004/39485.htm.

[97] "USDA Targeted Incentives for Greenhouse Gas Sequestration," USDA Fact Sheet, June 6, 2003, https://2001-2009.state.gov/g/oes/rls/fs/2004/39485.htm.

[98] "USDA Targeted Incentives for Greenhouse Gas Sequestration," USDA Fact Sheet, June 6, 2003, https://2001-2009.state.gov/g/oes/rls/fs/2004/39485.htm.

[99] "Provisions of Section 2709 of the Food, Conservation, and Energy Act of 2008 direct the U.S. Department of Agriculture (USDA) to prepare technical guidelines and science-based methods to measure environmental service benefits from conservation and land management activities, initially focused on carbon." See "Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory," USDA Technical Bulletin 1939, July 2014, p. 1, https://www.usda.gov/oce/climate_change/Quantifying_GHG/USDATB1939_07072014.pdf.

[100] "Strategic Plan: FY 2010 – 2015," *USDA*, undated, p. 17.

recognized concerns about climate change and have taken a number of affirmative steps to encourage GHG abatement in agriculture and forestry.

92. The USDA has also conducted extensive research on the feasibility and cost-effectiveness of GHG abatement methods in agriculture and animal production, as explained above in the discussion of ICF research. USDA has also implemented new GHG abatement programs, and supported GHG abatement in existing USDA programs.

93. The USDA has also sponsored research regarding the measurement of GHG emissions, and in 2014 published a comprehensive analysis of methods for measuring GHG fluxes (i.e., GHG emissions and removals) related to agriculture, ranching, and forestry.[101]

94. The USDA and other federal agencies also sponsor and conduct field research into land-use methods that mitigate or sequester GHG emissions. For example, the USDA's Current Research Information System provides documentation and reporting for relevant research conducted by or supported by agencies like the Agricultural Research Service and National Institute of Food and Agriculture.[102] The research is used to assist government policy makers in evaluating the effectiveness and economics of potential actions.[103] Such efforts may result in increasing agricultural productivity and thereby reducing GHG intensity (i.e., GHG emissions per unit of output). For example, research in the dairy industry has contributed to increased productivity; the industry produces more milk per cow, which often means less GHG emissions per unit of milk.[104]

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[101] "Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory," USDA Technical Bulletin 1939, July 2014, p. ES-1, https://www.usda.gov/oce/climate_change/Quantifying_GHG/USDATB1939_07072014.pdf.

[102] See "About CRIS," *USDA*, https://cris.nifa.usda.gov/aboutus.html. Using the CRIS Assisted Search function at https://cris.nifa.usda.gov/cgi-bin/starfinder/0?path=crisassist.txt&id=anon&pass=&OK=OK to find projects related to "greenhouse gases" and "abatement" reveals many studies of GHG abatement and closely related topics including Dr. Robertson's funded projects.

[103] "The Department conducts and invests in research to inform climate change policy and mitigation and adaptation strategies, tools and technologies. USDA will evaluate the effects of conservation actions to reduce greenhouse gas emissions to identify effective and economic approaches." See "Strategic Plan FY 2014 – 2018, *USDA*, undated, p. 16, https://www.ocfo.usda.gov/usdasp/sp2014/usda-strategic-plan-fy-2014-2018.pdf.

[104] "Reducing the Emissions Intensity of Livestock Production: Case Studies of Success," Global Research Alliance, 2018, p. 1, https://globalresearchalliance.org/wp-content/uploads/2018/02/LRG-case-study-USA-Dairy-CH4.pdf ("In 2014, the US national dairy herd produced twice as much milk with around 60% less cows than 90 years ago. These productivity gains – achieved through continuous improvements in animal genetics, nutrition, and management – have halved the enteric methane emissions per unit of milk produced in the US.").

95. The USDA has also implemented a Climate Change Science Plan that outlines priorities related to GHG mitigation in agriculture, ranching, and forestry. These priorities include developing and building from existing methodologies to measure and estimate carbon sequestration at a variety of scales; developing methods and practices to increase carbon sequestration; and analyzing "economic, GHG, and other environmental implications of alternative approaches to the design and implementation of GHG mitigation policies in the agriculture and forest sectors."[105]

96. The USDA has also initiated new GHG abatement programs. For example, the Building Blocks for Climate Smart Agriculture and Forestry program, which took effect in 2015, seeks to increase the amount of voluntary involvement by farmers, ranchers, forest landowners, and rural communities in a variety of efforts meant to reduce GHG emissions, increase carbon storage, and generate clean energy.[106]

97. Additionally, the USDA administers several longstanding conservation programs that support the use of practices and methods—some of them included in the list of proposed measures in the report by Dr. Robertson—that sequester or mitigate GHG emissions. These programs include the Environmental Quality Incentives Program ("EQIP"), the Conservation Stewardship Program ("CSP"), and the Conservation Reserve Program ("CRP").

- EQIP, first authorized in 1996, "provides financial and technical assistance to producers and land owners to plan and install structural, vegetative, and land management practices on eligible lands to alleviate natural resource problems." It does so by providing payments for producers to implement conservation practices. Conservation practices include crop rotations, cover crops, forest stand improvement, irrigation systems, livestock shelters, and reduced- and no-tillage farming methods.[107]

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[105] "USDA Climate Change Science Plan," *USDA*, undated, pp. 16–17, https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1043606.pdf.

[106] "USDA Building Blocks for Climate Smart Agriculture and Forestry Implementation Plan and Progress Report," *USDA*, May 2016, p. 2.

[107] Megan Stubbs, "Agricultural Conservation: A Guide to Programs," Congressional Research Service Report 7-500, April 17, 2018, p. 17; "Conservation Practices," *USDA*, https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849.

- CSP, first authorized in 2008, "provides financial and technical assistance to promote the conservation and improvement of soil, water, air, energy, plant and animal life, and other conservation purposes on tribal and private working lands."[108] It does so by providing five-year stewardship contracts which provide payments in return for participants "installing new conservation activities and maintaining existing activities." Activities include adopting a resource-conserving crop rotation, establishing no-till or reduced tilling systems, adding cover crops, switching to renewable energy sources, and improving forest stand management.[109]
- CRP, first authorized in 1985, provides a rental payment to farmers to retire environmentally sensitive land from agricultural production and to plant species that improve environmental quality. CRP has contributed to several environmental benefits. For example, in 2010, CRP efforts "resulted in the equivalent of a 52 million metric ton net reduction in carbon dioxide from CO2 sequestration, reduced fuel use, and nitrous oxide emissions avoided from not applying fertilizer."[110]

98. USDA also administers programs through USFS to protect public lands assigned to the U.S. National Forest system. USFS manages land use and restricts logging in the National Forest system through the National Forest Management Act of 1976 and Endangered Species Act of 1973.[111] To enhance the understanding of carbon storage potential within forests, USFS has been conducting research and implementing pilot programs across the United States.[112]

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[108] Megan Stubbs, "Agricultural Conservation: A Guide to Programs," Congressional Research Service Report 7-500, April 17, 2018, p. 13.

[109] Megan Stubbs, "Agricultural Conservation: A Guide to Programs," Congressional Research Service Report 7-500, April 17, 2018, p. 13; "CSP Activity List for Participants: Enhancements," *USDA*, January 2018, https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcseprd1378494&ext=pdf.

[110] "CRP Benefits," *USDA*, July 2011, p. 2, https://www.fsa.usda.gov/Internet/FSA_File/united_states.pdf.

[111] "National Forest Management Act of 1976," https://www.fs.fed.us/emc/nfma/includes/law.html; "Endangered Species Act of 1973," Digest of Federal Resource Laws of Interest to the U.S. Fish and Wildlife Service, https://www.fws.gov/laws/lawsdigest/esact.html.

[112] "Forest Inventory and Analysis: Fiscal Year 2016 Business Report," USDA Forest Service Report FS-1075, August 2017, pp. 47–48.

99. USDA also administers programs to conserve private forest land under the Healthy Forests Reserve Program ("HFRP"). HFRP, which was first authorized by the Healthy Forests Restoration Act of 2003, "assists landowners in restoring and enhancing forest ecosystems using 10-year agreements, 30-year contracts, 30-year easements, and permanent easements."[113] These agreements provide payments to landowners in return for forest conservation activities that "improve biodiversity, enhance carbon storage, and promote the recovery of fish, plants, and wildlife that are at risk of extinction."[114]

C. Government policy makers reject climate-change initiatives that fail to meet basic principles for sound policy formulation

100. Plaintiffs' criticism of USDA's alleged support for "polluting farming and agricultural practices" ignores the fact that in many instances, USDA has considered GHG abatement methods has chosen not to implement them either because the scientific evidence is inconclusive or because the practice is such that USDA cannot implement a cost-effective policy to facilitate adoption.

1. The science does not yet yield results that can be implemented

101. When the scientific research for a given GHG abatement method is so tentative or not strongly enough supported by evidence, USDA may reasonably conclude that it does not have the science backing needed to appropriately understand the outcomes and impact of the practice, which is an objective of USDA.[115] Plaintiffs do not account for USDA's substantial efforts in place to fill the knowledge gaps. These efforts are key to supplement the scientific knowledge base.

102. For example, a 2016 publication identified substantial barriers to the adoption of GHG abatement methods in agriculture and forestry, including uncertainty as to sequestration

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[113] Megan Stubbs, "Agricultural Conservation: A Guide to Programs," Congressional Research Service Report 7-500, April 17, 2018, p. 20.

[114] "Forests in the Farm Bill: A 2017 Progress Report and Recommendations," American Forest Foundation Report, 2017, p. 16, https://www.forestfoundation.org/stuff/contentmgr/files/1/97181b16014154f00ac6a61a807ae88a/files/fifb_2017report_9_25finalpages.pdf.

[115] "A key piece of that science is determining the outcomes and impacts of our work through accurate and reliable data." See "USDA Strategic Plan: FY 2018 – 2022," *USDA*, May 2018, p. 10, https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf.

potential, verification costs, concerns about the permanence of sequestration and the risk of reversal, and other scientific and methodological uncertainties.[116]

103. Similarly, a USDA-sponsored technical report on GHG emissions for agriculture and forestry published in 2011 identified several critical research needs to better estimate carbon sequestration. The needs included additional field studies across different regions and soil types where given management practices are being performed to understand the cost associated with the various mitigation strategies.[117] For example, the report concluded that additional studies needed to be performed to "clarify impacts of including perennials in annual crop rotations."[118]

104. Within the current USDA strategic plan, scientific rigor is included as a principle to guide its regulatory review and reform effort. In particular, the review is to ensure that the science and research underlying USDA decisions, policies, and regulations are "held to the highest standards of intellectual rigor and scientific integrity."[119]

105. To assist agro-ecosystem modelers, producers, program managers, and government policy makers, USDA created GRACEnet, a research program initiated in the early 2000s, to increase soil carbon sequestration and GHG mitigation by agricultural management.[120] The program's objectives are to evaluate the status and change of carbon sequestration and net GHG emissions for typical versus alternative methods. It also has the objective to determine the

[116] "United States Mid-Century Strategy for Deep Decarbonization," The White House, November 2016, p. 85 ("Scaling up soil carbon sequestration on cropland and grassland through carbon incentives could be challenging for multiple reasons, including regional and local uncertainty of sequestration potential, cost of verification of soil carbon sequestration, and concerns regarding the permanence of stored soil carbon and risk of reversal. There are also potential opportunities to incentivize enhanced soil carbon in forests, but similar scientific and methodological uncertainties present barriers to program design and measurement of performance. Additional research, data collection, and monitoring frameworks can help improve existing measurement and estimation tools and models and reduce verification costs.")

[117] ICF International and Colorado State University, "Greenhouse Gas Emissions from U.S. Agriculture and Forestry: A Review of Emission Sources, Controlling Factors, and Mitigation Potential," USDA Interim Project Technical Report # GS-23F-8182H, December 2011, https://www.usda.gov/oce/climate_change/techguide/Denef_et_al_2011_Review_of_reviews_v1.0.pdf.

[118] ICF International and Colorado State University, "Greenhouse Gas Emissions from U.S. Agriculture and Forestry: A Review of Emission Sources, Controlling Factors, and Mitigation Potential," USDA Interim Project Technical Report # GS-23F-8182H, December 2011, p. 43, https://www.usda.gov/oce/climate_change/techguide/Denef_et_al_2011_Review_of_reviews_v1.0.pdf.

[119] "USDA Strategic Plan: FY 2018 – 2022," *USDA*, May 2018, p. 9, https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf.

[120] "GRACEnet Home," *USDA*, https://www.ars.usda.gov/anrds/gracenet/gracenet-home/, accessed August 3, 2018.

environmental effects (water, air, and soil quality) of methods developed to reduce GHG emissions and increase soil carbon storage.[121]

2. The lack of a cost-effective policy mechanism

106. The USDA must follow legal and regulatory decision-making requirements,[122] including cost-benefit analysis, which has long been a hallmark of common-sense policy. For example, under an Executive Order "each agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs."[123] These requirements are also acknowledged and included in USDA documents.[124]

107. Moreover, the USDA is required to evaluate its actions by performing "sound benefit-cost and cost-effectiveness analyses" to confirm that its actions will "result in efficient resource allocation."[125] For example, rather than implementing expensive groundwater safety policies to

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[121] "Greenhouse Gas Reduction Through Agricultural Carbon Enhancement Network," *USDA*, July 2017, https://www.ars.usda.gov/ARSUserFiles/anrds/GRACENET%20brochure%20%20REVISED%20July%202017%20final.pdf.

[122] "Regulatory Decisionmaking Requirements," USDA DR 1512-1, March 14, 1997, pp. iii, iv, https://www.ocio.usda.gov/sites/default/files/docs/2012/DR1512-001_0.pdf ("Every regulatory action published by USDA must comply with applicable Executive Orders, statutes, and regulations, be legally sufficient, and be consistent with USDA policy and budget objectives. ... The Unfunded Mandates Reform Act of 1995 requires agencies to assess the impact of regulations containing Federal mandates. Title II of the Act requires Federal agencies, before promulgating a proposed rulemaking that is likely to result in a final rule that contains a Federal mandate that may result in the expenditure by State, local, or tribal governments in the aggregate, or by the private sector, of $100 million or more adjusted annually for inflation, in any one year, to prepare, among other things, an assessment of the anticipated costs and benefits of the mandate and the effect of the mandate on health, safety, and the natural environment.").

[123] The President of the United States (1993): Executive Order 12866, p. 2. See also, OMB Circular A-4, designed to assist rulemaking based on Executive Order 12866, which states that a basic element for good regulatory analysis is "an evaluation of the benefits and costs—quantitative and qualitative—of the proposed action and the main alternatives identified by the analysis." United States Office of Management and Budget Memo (2003): Circular A-4, "Regulatory Analysis," p. 2.

[124] As outlined in 1997, USDA regulatory guidelines included the need to prepare a risk assessment, hazard identification, exposure assessment, and a cost-benefit analysis. See "Regulatory Decisionmaking Requirements," USDA DR 1512-1, March 14, 1997, Appendix C-1 and C-2, https://www.ocio.usda.gov/sites/default/files/docs/2012/DR1512-001_0.pdf.

[125] USDA, "Subpart A - Economics Analysis and Conservation Planning," *National Resource Economics Handbook Part* 610, (Washington, DC: NRCS, 2012), p. 4 ("Federal government agencies are responsible for evaluating whether their actions will result in efficient resource allocation, generating a net positive balance between benefits and costs. Agencies are charged with considering and properly dealing with all of the elements of sound benefit-cost and cost-effectiveness analyses.").

prevent many deaths from water quality concerns, policy makers might instead invest in measures that would prevent even more deaths, such as providing in-home water filtration in some hard-to-reach rural areas. In doing so, the policy makers would balance possible deaths using the same economic resources. Or, for example, policy regarding food safety. Food safety regulations and policies impose certain costs and resources to help reduce the risk of death. While some improvements may be affordable, others are expensive. Government policy makers may find that a more efficient use of costs and resources is to spend these same costs and resources to "purchase an ambulance, or build a roadside guardrail" that might prevent even more deaths.[126]

108. Consistent with this requirement, USDA in its 2014–2018 strategic plan included core values to both "direct resources to where they are used most effectively" and to "[m]aximize the return on taxpayer investment."[127] Further, in its current strategic plan, a review of existing regulations, orders, and related guidance documents include the question, "Is it worth it? Does it impose costs that exceed benefits?"[128]

Executed this 13th day of August, 2018.

Daniel A. Sumner

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[126] Parke Wilde, Food Policy in the United States: An Introduction (Abingdon, UK: Routledge, 2013), p. 115.

[127] One of the core values of USDA is "Results Orientation—Measuring performance and making management decisions to direct resources to where they are used most effectively." In addition, a strategic goal of USDA is to "Maximize the return on taxpayer investment in USDA through enhanced stewardship activities of resources and focused program evaluations." See "Strategic Plan: FY 2014 – 2018," *USDA*, undated, pp. 2–4, https://www.ocfo.usda.gov/usdasp/sp2014/usda-strategic-plan-fy-2014-2018.pdf.

[128] "USDA Strategic Plan: FY 2018 – 2022," *USDA*, May 2018, p. 9, https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf.

Appendix A

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Education

University of Chicago, Ph.D., 1978, Economics (Labor Economics and Agricultural Economics)
University of Chicago, M. A., 1977, Economics
Michigan State University, M. A., 1973, Economics
California State Polytechnic University, San Luis Obispo, B. S., 1971, Agricultural Management

Current Positions and Professional Experience

1997 -	Director, University of California Agricultural Issues Center
1993 -	Frank H. Buck, Jr. Professor, Department of Agricultural and Resource Economics, University of California, Davis
2011 - 2014	Executive Director, UC Davis Agribusiness Executive Seminar
1992-1993	Assistant Secretary for Economics, U.S. Department of Agriculture
1990-1992	Deputy Assistant Secretary for Economics, U.S. Department of Agriculture
1987-1991	Professor, Department of Economics and Business, North Carolina State University (on leave, September 1987- February 1989 and January 1990- December 1991)
1987-1989	Senior Staff Economist, President's Council of Economic Advisers
1986-1987	Resident Fellow, National Center for Food and Agricultural Policy, Resources for the Future, Washington, DC
1978-1987	Assistant-Associate Professor, Department of Economics and Business, North Carolina State University
1977-1978	Rockefeller Foundation Post-Doctoral Fellow, Labor and Population Group, Economics Department, Rand Corporation, Santa Monica, CA

Professional Awards, Honors and Distinctions

Keynote Speaker IFPRI-CAU Symposium, Beijing China, October 2017
Keynote Speaker, Korean Agricultural Economics Association, July 2017
Best Journal Article, *Agricultural Economics* for 2016, awarded August 2017
Snyder Memorial Lecture, Purdue University, April 2017
Filley-Garey Lecture, University of Nebraska, April 2016

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Fellows Lecture, Agricultural and Applied Economics Association, July 2015
Best Journal Article, *American Journal of Agricultural Economics,* 2015
Associate Editor, *Australian Journal of Agricultural and Resource Economics*, 2010-2013
Associate Editor, *Journal of Wine Economics*. 2007-
Associate Editor, *China Journal of Agricultural Policy*. 2008-
Keynote speaker at the German Agricultural Economics Association Annual Conference, 2009
Keynote speaker at the Agricultural Economics Society Conference, Reading England, 2007
Award for Quantity of Communication, Australian Society of Agricultural and Resource Economics, 2006
Best Journal Article, *Australian Journal of Agricultural and Resource Economics*, 2006
Outstanding Journal Article, *Review of Agricultural Economics*, 2006 (honorable mention)
Fulbright Senior Specialist Scholar, Australia, September 2002
USDA Agricultural Policy Advisory Committee for Trade (APAC), 2001-2003
Fellow, American Agricultural Economics Association, 1998
Award for Quality of Research Discovery, American Agricultural Economics Association, 1996
Award for Quality of Communication, American Agricultural Economics Association, 1996; Honorable Mention, 1991
Award for Outstanding Published Research in Agricultural Economics, Honorable Mention, Western Agricultural Economics Association, 1996
Award for Distinguished Policy Contribution, American Agricultural Economics Association, 1995
Tobacco Economics Award, Tobacco Merchants Association, 1993
Honored Alumnus, College of Agriculture, California State Polytechnic University, 1991
Associate Editor, *Tobacco Science*, 1989-1991
Associate Editor, *American Journal of Agricultural Economics*, 1986-1990
Member and author, Council for Agricultural Sciences and Technology Task Force on the 1985 Farm Bill

National Policy Service

As Senior Staff Economist at the President's Council of Economic Advisers, I provided analysis to support the evaluation of policy options on economic issues facing the U.S. government. As USDA Assistant Secretary for Economics, I had responsibility for the oversight and guidance of data collection, projections, economics research, and policy analysis for U.S. agriculture. I supervised several agencies including more than 1,000 professional economists and statisticians. I provided agricultural policy information and counsel to the Secretary and other senior government officials.

U.S. Congress, State Legislature, U.S. International Trade Commission, Canadian International Trade Tribunal and World Trade Organization Testimony

Testimony before the World Trade Organization Dispute Settlement Panel on 21.5 Implementation Panel on Country of Origin Labeling of Live Cattle and Hogs, 2015
Testimony before the World Trade Organization Dispute Settlement Panel and Appellate Body on Country of Origin Labeling of Live Cattle and Hogs, 2009, 2010, 2012.
Testimony before the Canadian International Trade Tribunal on U.S. corn subsidies (2006)

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Testimony before committees of the California State Assembly and Senate. Most recently on economic issues surrounding BSE (August 2005).

Testimony before the World Trade Organization Dispute Settlement Panel and Appellate Body on U.S. upland cotton subsidies (2003, 2004, 2007 and 2009).

Testimony before the U.S. International Trade Commission on relief from import controls, imposition of new import barriers, anti-dumping, countervailing duties, and import safeguards (1992, 1994, 1998, 1999, 2000, 2002, 2003, 2004, 2010).

Testimony before U.S. House of Representatives Committee on Agriculture and Subcommittee on Agricultural Appropriations (1990, 1991 and 1992).

Testimony before the U.S. Senate Committee on Agriculture, Nutrition and Forestry and the Committee on Energy and Natural Resources. Topics included farm programs, economic outlook, wine industry, and irrigation policy reform among others (1990, 1991 and 1992).

Publications

Books

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Antle, John M. and Daniel A. Sumner. 1996. Editors. *The Economics of Agriculture: Volume 2, Papers in Honor of D. Gale Johnson*. Chicago, Illinois: University of Chicago Press.

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Professional Journal Articles

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Lee, Hyunok, William A. Matthews, and Daniel A. Sumner. 2017. "Korean Free Trade Agreement Renegotiation: California Agriculture Has Much to Lose." ARE Update 21(2): 1–4.

Lee, Hyunok, Antoine Champetier, Daniel A. Sumner, and Jennifer Bond. 2017. "Bee-conomics Revisited: A Decade of New Data Is Consistent with the Market Hypothesis." ARE Update 20(5):1–4.

Anderson, Nina M. and Daniel A. Sumner. 2016 "Which California Foods You Consume Makes Little Impact on Drought-Relevant Water Usage." *ARE Update* 19(3):5-8.

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Recent University Research Grants and Contracts

2016-2018	Assessing Effects of Federal Crop Insurance on Supply of Specialty Crops, USDA (480,00)
2015-2017	California Sustainable Winegrowers. Accelerating Adoption of Innovative Conservation and Sustainable Best Management Practices. ($19,000)
2015-2016	California Department of Food and Agriculture. Contributions of California Agriculture to the State Economy, California Department of Food Agriculture, ($48,000)
2014-2019	NIH/NIDDK. Translating Obesity and Diabetes Prevention into the Worksite for Immigrant Populations. Co-Principal Investigator. (Economics portion, $403,000)
2014-2017	UCD Viticulture and Enology. Review case studies to illustrate the return on research investments. ($18,000)
2014-2017	Gallo Foundation. Review case studies to illustrate the return on research investments. ($10,000)
2014-2016	US Department of Agriculture. CRP Land Management & Pollinators ($75,000)
2014-2015	California Almond Board. Contributions of the California Almond Industry to Local, State, National and Global Economies. ($46,000)
2014-2015	Center for Food Integrity. The Effects on Consumer Costs of Different Hen Housing Systems. ($28,000)
2012-2016	NIFA-USDA flow through from MSU. Developing Sustainable Pollination Strategies for US Specialty Crops. ($370,000)
2011-2013	CDFA-USDA Specialty Crops Grant. Effects of Quality Measurement and European Policy on Olive Oil Market Prospects. ($121,000)
2011-2012	Giannini Foundation. Pollination Economics. ($20,000)
2011-2012	CalEPA. Evaluation of options for reduced pesticide use in greenhouse and nursery production ($55,000.)
2011	California Association of Winegrape Growers. Economic Effects of Import Duty Drawbacks and Excise Tax Refunds. ($35,000)
2011	CDFA. The Development and Evaluation of Market Incentives and Infrastructure Alternatives to Enhance Delta Agriculture ($30,000)
2010	California Seed Association. The economic role and contributions of the California seed industry ($35,000)
2010-2013	Coalition for Sustainable egg Supply. Evaluation of economics of housing for egg production. ($122,000)
2010-2012	USDA-ERS Cooperative Agreement. Food Safety and Traceability ($88,000)
2010-2012	CDFA-USDA Specialty Crops Grant. Evaluation of marketing margins for fruit and vegetables ($220,000), with Hyunok Lee.
2009-2011	Coalition for Sustainable egg Supply. Egg economics and housing. ($40,000)
2009-2011	California Energy Commission. Climate change in Yolo County. ($40,000)

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2009	CDFA. California Agricultural Vision 2030 ($20,000)
2008	Packard Foundation. Agricultural Nitrogen Assessment for California ($600,000),
2007-2009	Chevron. Economics of Biofuels Feedstock in California Projections Based on Policy and Market Conditions. ($351,000)
2007-2008	Iowa State University AgMRC Sub-Contract (USDA Federal Flow-Through). Agricultural Marketing Resource Center Plan of Work for 2007/2008 Part B-C, Product Differentiation, Value-Added Products and Government Regulations: Commodity Profiles. ($220,000)
	with UC Davis Agricultural Sustainability Institute.
2006-2008	Solano County Board of Supervisors. Economic Prospects for Agriculture in Solano County California ($110,000)
2006-2007	Iowa State University AgMRC Sub-Contract (USDA Federal Flow Through). Implications for Expanded Bioenergy Production in Importing Regions. ($95,000)
2006-2007	California Department of Food and Agriculture. Pest List Development/Research. ($44,000)
2004-2006	California State University, Fresno, Agricultural Research Initiative. Economics of Traceability ($81,000)
2004-2005	USDA, FAS through the California Winegrape Growers Association. *Assessing the Emerging Market for U.S. Wine in China*, with Rozelle ($140,000)
2004-2005	California Association of Winegrape Growers. Wine markets in China ($66,100)
2004-2005	California State University, Fresno. Economic analysis of markets for grape juice concentrate ($22,300)
2004	CDFA/California State Polytechnic University, San Luis Obispo. Assessment of the Payoff to Exotic Pest Programs ($25,000)
2003-2005	USDA Economic Research Service. Economics of Invasive Species and Commodity Programs ($150,000)
2003-2004	Giannini Foundation ($14,026)
2003-2004	USDA Risk Management Agency. *Risk Management Education for California*, ($498,000)
2002-2004	USDA National Research Initiative. Economics of efforts to eradicate FMD in the Mercosur, with Jarvis and Univ. Illinois ($160,000)
2002-2003	California Department of Water Resources. Assessing irrigation demand by California agriculture in 2030, with Howitt ($57,000)
2002-2003	FAO. Improving the FAO meta database (ABCDQ) ($7,000)
2002-2003	USDA Economic Research Service. Effects of U.S. national dairy policy ($25,000)
2001-2007	USDA Rural Development Administration. Creation of the Agricultural Marketing Resource Center, with Iowa State University and Kansas State University (AIC portion approximately $300,000 per year)
2001-2004	USDA Risk Management Agency. Producer input expenditure studies to support crop insurance programs, with Klonsky ($940,000)
2001-2003	USDA, National Research Initiative. Asian dairy trade, with Beghin and Lee ($160,000)
2001-2002	Western Agricultural Health and Safety Center. Farmer and worker health economics and policy ($20,000)

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2000-2002	Giannini Foundation. Effects of milk marketing orders, ($12,000)
2000-2001	UC DANR Workgroups. Processing tomato industry on the competitive edge ($17,000)
1999-2001	California League of Food Processors. Effects of EU policy for processing tomatoes ($27,000)
1998-2000	USDA National Research Initiative. Climate forecasts and grain markets. ($127,000)
1998-1999	USDA APHIS, California Department of Food and Agriculture; and UC/DANR. Implications of polices for control of exotic pests and diseases. ($130,000)
1998-1999	National Oceanographic and Atmospheric Administration. Economic implications of improved climate forecasts for agricultural markets in the Pacific Rim ($63,000)
1997-2015	California Department of Food and Agriculture. Annual grant to prepare California Agricultural Export Statistics ($12,000 - $20,000 per year)
1997-2000	US-Israel Bi-national Agricultural Research and Development Fund. Off-farm work by farm family members, with Chalfant and Kimhi ($169,000)
1997-1998	USDA, National Research Initiative. Implications of elimination of Foot and Mouth Disease, with Jarvis ($71,000)
1997-1998	National Oceanographic and Atmospheric Administration. Agricultural economic implications of improved climate forecasts ($20,000)

Teaching and Graduate Student Supervision

Recent courses include micro-economic theory; wine markets, management and economics; agricultural policy analysis and the economics of agricultural sustainability. Previous courses include a course in agricultural policy for Chinese Ph.D. students in Beijing, economic development and econometrics. Graduate student advising includes supervision of several Ph.D. students or post-doctoral fellows each year.

Professional Memberships and Recent Activities

Agricultural and Applied Economics Association
    Professional Activities Committee,
    Chair, Policy Award Committee,
    Fellows Selection Committee,
American Association of Wine Economics
American Enterprise Institute Adjunct Scholar
Western Agricultural Economics Association
    Council Member,
    Chair best published research award committee
International Association of Agricultural Economists

International Agricultural Trade Research Consortium
    Director,
    Chair,
Past memberships:

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American Economic Association
Econometric Society
Rice Technical Working Group
Co-chair, Economics Program
Australian Agricultural Economics Society
Western Economic Association

Academic Reviewer

Journal of Political Economy, Journal of Wine Economics, Agricultural Economics, California Agriculture, Journal of Law and Economics, Review of Agricultural Economics, Australian Journal of Agricultural and Resource Economics, American Journal of Agricultural Economics, Choices, Economic Development and Cultural Change, Science, USDA, National Research Initiative, National Science Foundation, Fulbright Foundation, among others

Selected University Committee Service

2015-16	University Search Committee for director of the World Food Center
2015-17	Department Faculty Search Committee
2013-18	Organizer, ARE Department Agricultural Economics Workshop
2009-	Executive Committee Center for Regional Change
2013-14	University Student Awards committee
2011-2013	College Student Awards Committee
2009	Chair ARE Department Faculty Search Committee
2008-09	Chair, ARE Department Seminar
2008	College of Agriculture and Environmental Science, Ad Hoc Dairy Research Planning Committee
2008	Agricultural Sustainability Institute Conference Program Committee
2008	University of California, Division of Agriculture and Natural Resources Chair of Committee to Project the Future of California Agriculture
2007-	UC Davis, Center for Regional Change, Academic Advisory Committee
2007	University of California Cooperative Extension, Oral History Project Committee
2007	Department of Human and Community Development, Search Committee
2005-06	College of Agriculture and Environmental Science, Strategic Planning Committee
2004-05	CAES, Implementation and Director Search Committee for the Institute for Sustainable Agriculture
2004-06	ARE Department Search Committee
2003-05	College of Agriculture and Environmental Sciences, Outreach Review Committee
2003	Ad hoc UC, DANR committee on funding Cooperative Extension
2003	Ad hoc UC, DANR committee on reorganization of DANR operations
2001	ARE Department Undergraduate Program Committee
2000	Program Committee, UC Division of Natural Resources, Biennial Convention
2000	Department Faculty Search Committee
2000	Management Evaluation Committee for the UC Center for Cooperatives
1999	UC Davis Joint Personnel Committee

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1996-1999	UC, DANR, Program Planning Advisory Committee: Chair, Program Integration and Committee of the Whole; Chair, Agriculture Subcommittee
1998	Selection Committee, Director of the UC Davis Gifford Center on Population Studies
1998	California Dairy Research Foundation, Research Advisory Committee
1997	Provost's Globalization Commission
1995-1997	Master Advisor and Chair, Department Undergraduate Committee
1995- 1999	Executive Committee and Advisor, Graduate Group in International Agricultural Development
1994-1999	Technical Advisory Committee, California Rice Research Board
1994-1997	Standing Committee on International Programs, CAES, Chair 1996-1997.

Appendix B

Testimony of Professor Daniel A. Sumner in the Last Four Years

Animal Legal Defense Fund v. United States Food & Drug Administration. United States District Court, Northern District of California, San Francisco Division, Case No. 3:12-cv-04376-EDL. Expert report and deposition: 2017. Testimony: 2018.

Country of Origin Labeling Requirements. World Trade Organization Dispute Number 384. Testimony: 2015.

Western Sugar Cooperative, et al. v. Archer-Daniels-Midland Company, et al. United Sates District Court for the Central District of California, Case No. 2:11-cv-03473. Expert reports and deposition: 2014.

Appendix C
Documents Relied Upon

Document Title	Document Date
Complaint	
First Amended Complaint for Declaratory and Injunctive Relief, *Kelsey Cascadia Rose Juliana et al. v. The United States et al.*	September 10, 2015
Expert Report	
Expert Report of Dr. G. Philip Robertson	April 13, 2018
Academic Articles	
Abram Bergson, "A Reformulation of Certain Aspects of Welfare Economics," *Quarterly Journal of Economics* 52, no. 2, pp. 310–334	1938
Adam Reimer et al., "Moving Toward Sustainable Farming Systems: Insights from Private and Public Sector Dialogues on Nitrogen Management," *Journal of Soil and Water Conservation* 72, no. 1, pp. 5A–9A	2017
Alison J. Eagle et al., "Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature," *Nicholas Institute for Environmental Policy Solutions: Duke University* Third ed., pp. 1–76	2012
Cameron M. Pittelkow et al., "When Does No-Till Yield More? A Global Meta-Analysis," *Field Crops Research* 183, https://www.sciencedirect.com/science/article/pii/S0378429015300228	2015
Colin A. Carter et al., "Commodity Storage and the Market Effects of Biofuel Policies," *American Journal of Agricultural Economics* 99(4), pp. 1027–1055	March 15, 2016
Brian C. Murray, "Carbon Values, Reforestation, and 'Perverse' Incentives Under the Kyoto Protocol: An Empirical Analysis," *Mitigation and Adaptation Strategies for Global Change* 5, pp. 271–295	2000
E. B. Schwab et al., "Conservation Tillage Systems for Cotton in the Tennessee Valley," *Soil Science Society of America Journal* 66, no. 2, pp. 569–577	2002
G. Cornelius Van Kooten et al., "Effect of Carbon Taxes and Subsidies on Optimal Forest Rotation Age and Supply of Carbon Services," *American Journal of Agriculture Economics* 77, pp. 365–374	1995
G. Philip Robertson et al., "Cellulosic Biofuel Contributions to a Sustainable Energy Future: Choices and Outcomes," *Science* 356, pp. 1–9	2017
G. Philip Robertson et al., "Farming for Ecosystem Services: An Ecological Approach to Production Agriculture," in *The Ecology of Agricultural Landscapes: Long-Term Research on the Path to Sustainability*, ed. S. K. Hamilton et al. (New York: Oxford University Press)	2015
James Hansen et al., "Assessing 'Dangerous Climate Change': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature," PLoS ONE 8(12): e81648, pp. 1–26	2013
Harry de Gorter and David R. Just, "The Social Costs and Benefits of Biofuels: The Intersection of Environmental, Energy and Agricultural Policy," *Applied Economic Perspectives and Policy* 32, no. 1, pp. 4–32	2010
John Stumbos, "Methane Generators Turn Agricultural Waste Into Energy," *California Agriculture* 55, no. 5, pp. 8–9.	2001
Lee R. Lynd et al., "Cellulosic Ethanol: Status and Innovation," *Current Opinion in Biotechnology* 45, pp. 202–211	2017

Document Title	Document Date
Matthew D. Hurteau et al., "Carbon Protection and Fire Risk Reduction: Toward a Full Accounting of Forest Carbon Offsets," Frontiers in Ecology and the Environment 6(9), pp. 493–498	November 2008
Michael A. Toman and P. Mark S. Ashton. "Sustainable Forest Ecosystems and Management: A Review Article," Forest Science 42(3), pp. 366–377.	1996
P. Lusk, "Methane Recovery from Animal Manures: The Current Opportunities Casebook," NREL Report SR-580-25145	September 1998
Parke Wilde, *Food Policy in the United States: An Introduction* (Abingdon, UK: Routledge)	2013
Richard T. Conant et al., "Grassland Management Impacts on Soil Carbon Stocks: A New Synthesis," *Ecological Applications* 27, no. 2, pp. 662–668	2017
Stephen M. Ogle et al., "No-Till Management Impacts on Crop Productivity, Carbon Input and Soil Carbon Sequestration," *Agriculture, Ecosystems and Environment* 149, pp. 37–49	2012

Reports

Document Title	Document Date
"California Dairy Review" Volume 22, Issue 7, https://www.cdfa.ca.gov/dairy/uploader/docs/CDR%20JUL%2018.pdf	July 2018
"Climate Impacts on Agriculture and Food Supply," *EPA*, undated, https://archive.epa.gov/epa/climate-impacts/climate-impacts-agriculture-and-food-supply.html, accessed August 3, 2018	
David Dawe ed., *The Rice Crisis: Markets, Policies and Food Security* (Earthscan, 2010), http://www.fao.org/3/a-an794e.pdf.	2010
"Forest Inventory and Analysis: Fiscal Year 2016 Business Report," USDA Forest Service Report FS-1075	August 2017
"Forests in the Farm Bill: A 2017 Progress Report and Recommendations," American Forest Foundation Report, https://www.forestfoundation.org/stuff/contentmgr/files/1/97181b16014154f00ac6a61a807ae88a/files/fifb_2017report_9_25finalpages.pdf	2017
ICF International and Colorado State University, "Greenhouse Gas Emissions from U.S. Agriculture and Forestry: A Review of Emission Sources, Controlling Factors, and Mitigation Potential," USDA Interim Project Technical Report # GS-23F-8182H, https://www.usda.gov/oce/climate_change/techguide/Denef_et_al_2011_Review_of_reviews_v1.0.pdf	December 2011
ICF International "Greenhouse Gas Mitigation Options and Costs for Agricultural Land and Animal Production within the United States," USDA Report No. AG-3142-P-10-0214	February 2013
ICF International, "Managing Agricultural Land for Greenhouse Gas Mitigation within the United States," USDA Report Contract No. AG-3144-D-14-0292	July 2016
"Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2016," EPA Report 430-R-18-003	April 12, 2018
"Manure Use for Fertilizer and for Energy," USDA Report to Congress	June 2009
Megan Stubbs, "Agricultural Conservation: A Guide to Programs," Congressional Research Service Report 7-500	April 17, 2018
"Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory," USDA Technical Bulletin 1939, https://www.usda.gov/oce/climate_change/Quantifying_GHG/USDATB1939_07072014.pdf	July 2014
"Reducing the Emissions Intensity of Livestock Production: Case Studies of Success," *Global Research Alliance*, https://globalresearchalliance.org/wp-content/uploads/2018/02/LRG-case-study-USA-Dairy-CH4.pdf	2018
"Strategic Plan: FY 2010 – 2015," *USDA*, undated	
"Strategic Plan: FY 2014 – 2018," USDA, undated, https://www.ocfo.usda.gov/usdasp/sp2014/usda-strategic-plan-fy-2014-2018.pdf	

Document Title	Document Date
United States EPA, *Greenhouse Gas Mitigation Potential in US Forestry and Agriculture*	2005
United States Government Accountability Office Report, "Renewable Fuel Standard: Program Unlikely to Meet Its Targets for Reducing Greenhouse Gas Emissions," https://www.gao.gov/assets/690/681252.pdf	November 2016
"United States Mid-Century Strategy for Deep Decarbonization," The White House	November 2016
"USDA Building Blocks for Climate Smart Agriculture and Forestry Implementation Plan and Progress Report," *USDA*	May 2016
"USDA Climate Change Science Plan," *USDA*, undated, https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1043606.pdf	
"USDA Strategic Plan: FY 2018 – 2022," *USDA*, https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf	May 2018
USDA, "Subpart A - Economics Analysis and Conservation Planning," *National Resource Economics Handbook Part 610*, (Washington, DC: NRCS)	2012

Publicly Available Materials

"About CRIS," *USDA*, https://cris.nifa.usda.gov/aboutus.html	
"Cheap No More," *The Economist*, https://www.economist.com/briefing/2007/12/06/cheap-no-more, accessed August 3, 2018	December 6, 2007
"Climate," *ICF*, https://www.icf.com/work/climate, accessed August 3, 2018	
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Note: In addition to the documents on this list, I considered all documents cited in my report and my exhibits to form my opinions.